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The experience curve and limit pricing as means of integrating portfolio matrices into capital budgeting.

Marshall, Paul S.

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THE EXPERIENCE CURVE AND LIMIT PRICING AS MEANS OF INTEGRATING PORTFOLIO MATRICES INTO CAPITAL BUDGETING

Submitted by

PAUL S. MARSHALL

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SUMMARY

This thesis develops a model for the net present value to the firm of a strategy of increasing an SBU's market share as a function of four quantitative variables: the firm's initial market share, the current position in the product life cycle, as viewed by the firm, the competitor's relative experience curve slope and the competitor's view of the shape and size of the product life cycle. The net present value is calculated using traditional definitions, but includes a limit pricing strategy by the firm and assumes the existence of the experience curve.

The prime reason for the development of this model is to test quantitatively the capital budgeting implications of the portfolio matrices proposed by the Boston Consulting Group and McKinsey and Company. And, to suggest a format that better integrates corporate strategy and finance.

The most important finding of this research is that the inclusion of experience curve effects causes relative market share to assume dominance

over market growth rate in the BCG matrix and causes business strength to assume dominance over industry attractiveness in the McKinsey matrix, at least within the limitations and assumptions of the model. Put into laymen's terms, that means that corporate planners should abandon attempts to convert low share but high growth businesses (what BCG calls "Problem Children") into "Stars", if such conversion can only be accomplished through price, or price equivalent competition, as long as both participants are equally competent.

A second important finding is that other variables, beyond growth and share, can be successfully and quantitatively incorporated into the model. This means that the two-dimensional approach of the Boston Consulting Group can be improved upon by adding additional variables or that businessmen can make better use of the McKinsey approach to strategy and its investment implications, by logically quantifying their variables.

ACKNOWLEDGEMENTS

I am most grateful to Professor Cyril R. Tomkins of the University of Bath, who as my supervisor helped me immeasurably to formulate and refine the content of this research. His critique, always timely and rigorous, was both instructive and enjoyable.

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TABLE OF CONTENTS

TABLE OF CONTENTS

(continued)

TABLE OF CONTENTS

(continued)

PAGE NUMBER

TABLE OF CONTENTS

(continued)

TABLE OF CONTENTS

(continued)

PAGE NUMBER

TABLE OF CONTENTS

(continued)

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CHAPTER 1

GENERAL INTRODUCTION

Business has long recognized that among the most important decisions it has to make, indeed one on which its very survival depends, is the decision on which businesses it should be in and how to allocate its scarce resources among those businesses. Traditionally, this dual problem of business has been addressed by two related, but certainly not integrated disciplines, strategic planning and finance.

Ansoff (1965:18-19), the great "guru" of corporate strategy, has defined both the problem of deciding what business the firm is in and what kinds of businesses it will seek to enter, and the choice of resource commitments among alternatives, as strategic decisions. Finance, through its capital budgeting theory, has addressed the same questions in its own ways. However, in my view, no quantitative model has ever been proposed that successfully links strategic planning and finance. A proposal for that quantitative link is the ambitious goal of this thesis.

Background

Clearly the question of how the firm should allocate its scarce resources among investment opportunities is an important one. Both finance and strategic planning have addressed it, albeit from different starting points and using different tools. I personally am uncomfortable with each method standing alone, but I believe that if the two disciplines are better linked, a more complete answer to this important question can be developed.

As a starting point for this work, let me briefly review my concerns with both the approaches of finance and strategic planning to the firm's investment problem. Naturally, all the concepts discussed in this brief introductory chapter are more fully addressed in the appropriate sections of this thesis.

The capital budgeting theory of finance, clearly the older of the two disciplines, has historically looked at the investment decision from the perspective of the fixed assets to be acquired, and perhaps the associated working capital, and not necessarily the business in which those assets are employed. The reason for this focus undoubtedly resulted from the need in discounted cash flow analysis to define a useful life. Capital assets have a reasonably short life based on physical wear or obsolescence; businesses, however, may last for generations.

Capital budgeting theory suggests that the proper way to analyze investment proposals is to calculate an incremental net cash flow and then to discount it at the firm's cost of capital to give net present value. The rule then, assuming independence and no capital rationing, is to accept all such investments with NPV greater than zero. The logic is that: (1) only incremental effects are important in decisions, (2) only cash flow effects are important (not earnings) because only cash has a time value, and (3) net present value is the appropriate yardstick of value because, in theory, increases in NPV directly increase the value of the firm, the goal assumed paramount in capital budgeting.

The logic of capital budgeting theory, assuming only NPV matters, is irrefutable. However, in implementation certain problems develop. Undoubtedly, it was exactly these problems that caused the development of certain strategic planning tools such as the portfolio matrices. First, cash flow analysis, even for the relatively short life span of fixed assets, requires forecasts be made for sales volumes, prices, costs, investment requirements, tax rates, and the cost of capital over that life time. Businessmen have found it uncomfortable to make such forecasts. The reasons are understandable! Forecasting accuracy declines rapidly with time. Forecasts of the order of magnitude of a decade away can be nothing more, practically speaking, than extrapolations of current trends. Considering that there is little to assist forecasters in predicting the long term path of costs and prices, and practically nothing, save a crystal ball, to predict competitive reaction, external shocks, tax rates, and inflation, it is not surprising that most forecasts of net cash flow beyond a year or two away are made only with a low degree of confidence.

Second, businessmen know intuitively that it is a business they are really investing in, not fixed assets and working capital. Capital budgeting theory has no way to consider investing in a business except to link together fixed asset acquisitions as they wear out or become obsolete, and expand them as the market grows. Such an approach only compounds the uncertainty and uncomfort of long term forecasts by making them even longer.

Third, and perhaps most importantly, business needs to develop reliable incremental net cash flows. Considering only asset acquisitions, incremental net cash flows appear easy. For expansion type proposals, clearly the largest category for most businesses, the difference between acquiring a fixed asset and not acquiring it is simply the cash flows from the acquisition, since no cash flows result if the asset is not acquired. However, from the perspective of investment in a business, the difference is not as clean. If the firm fails to invest, and competition does, it is possible (and I believe from conclusions about the experience curve, highly likely) that the long term attractiveness of the business to the firm will be impaired. Traditional capital budgeting provides no explicit framework for addressing this dilemma.

Such problems with implementing the quantitatively elegant capital budgeting theory of finance have lead to the development of a much less quantitative approach. Strategic planning switched the approach from fixed asset acquisition analysis to the management of and support for the strategic business unit. Strategic planning suggests continual monitoring of specific opportunities and risks within the SBU's industry and specific strengths and weaknesses within the firm. They suggest this will aid in predicting future developments, lower the reaction time to current changes and help define what may be "special" about individual investment proposals.

The General Electric Company and McKinsey and Company carried such ideas through to investment implications with their "Business strength-Industry attractiveness" matrix. They conclude that if an SBU is above average on at least one axis and never below average, then the firm should invest. The McKinsey approach is highly qualitative in that both axes can include whatever the firm feels important, and no attempt is made to justify any weights given the various factors.

The Boston Consulting Group, starting from the assumption that total cash flows within the firm should be balanced, developed the cash flow implications through their "Growth-Share" matrix. Both growth and share are readily quantifiable and BCG implied relative investment attractiveness (i.e., "Stars" are better than "Dogs") as a function of two variables alone.

Regarding strategic planning, particularly the matrix approach to investment attractiveness, my concerns are many. The McKinsey's matrix may be an excellent debating tool within the firm to highlight relevant factors for investment analysis, but what logic leads us to believe that an SBU is attractive for investment only as long as it is above average on at least one axis and never below average? The construction of the matrix assumes symmetry of importance between business strength and industry attractiveness. What logic demands equal importance? Further, how can we practically use such a tool with vague definitions of the axes and no help in weighing the relative importance of the many variables on each axis or even assistance in defining what is average and above and below.

The Boston Consulting Group's "Growth-Share" matrix appears on the surface to be something with more meat. However, what logic demands that a firm's cash flows be balanced among SBUs? Shouldn't some firms attract outside financing if their investment opportunities are particularly attractive? Similarly, shouldn't others contract in size through large dividend payments if good reinvestment opportunities do not exist? Further, an essential question, why should investment attractiveness be a function of only growth and share? Are not other factors important? The competitive environment immediately comes to mind. Again, how can we tell which axis is most important? In a world of capital rationing, that question will inevitably arise and we will need to know.

What is needed to link the seemingly divergent approaches of finance and corporate strategy? I believe, as a first step, we need a model based on the logic of incremental cash flow and net present value that:

1. Looks at investments in the market share of businesses, not asset acquisition.

2. Provides a tool to predict long term prices, costs and investments that is believable.

3. Allows a meaningful way to calculate incremental net cash flows, considering the NPV of not investing in existing businesses is negative, not zero, if the experience curve phenomenon is important.*

4. Considers all factors effecting investment attractiveness, not just growth and share.

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* As discussed further in Chapter 4

5. Is quantitative, not qualitative.

Little, if any, work on a quantitative link between strategic planning and capital budgeting has been done except perhaps various conceptual attempts at a link by Tomkins (1979-1984), and McCosh, Rahman and Earl (1981). This work attempts to build on that base. Specifically, by building a model that measures the net present value of a decision by the firm to increase its market share as a function of four variables: the firm's initial market share, the current position in the product life cycle as viewed by the firm, the competitor's relative experience curve slope, and the competitor's view of the shape and size of the product life cycle. In that sense, this thesis fits between the Boston Consulting Group's portfolio matrix, in that it considers more variables, and McKinsey's portfolio matrix, in that it is more quantitative. Different from both matrix approaches, it does not presuppose symmetry.

This background section is meant to define where I am "coming from" in writing this thesis -- my concerns, and my plan of attack. As already mentioned, the concepts discussed in this brief introductory chapter are more fully addressed in the appropriate sections later on.

Statement of objectives

The overall objective of this thesis is to provide a model that will measure the financial attractiveness to the firm of investing in current or potential strategic business units (SBUs). The measure of financial attractiveness used will be the familiar net present value from traditional capital budgeting theory. The refinement proposed, in fact the reason this thesis is written, is the attempt to include quantitatively the generally qualitative considerations of corporate strategic planning into the firm's capital budgeting decision.

The first specific objective of this thesis is to quantify the incremental change in the net present value of investment in increased market share in an SBU with respect to incremental changes in what McKinsey and Company might call "industry attractiveness" and "business strength". The result of such a calculation is to allow the mapping, with constant isobars of net present value, of the portfolio matrices proposed by McKinsey and BCG to measure the attractiveness of investing in an SBU.

The second specific objective of this thesis is to demonstrate how the model can be used to assist strategic planners in their search for candidate SBU's, both internally to the firm and externally, to aid the firm in satisfying its objectives over the strategic planning horizon.

Scope of the study

This thesis is theoretical, rather than experimental or comparative, in nature. It combines ideas from many disciplines -- marketing, cost accounting, microeconomics, finance, and strategic planning -- into a model that describes the attractiveness of investing in an SBU. Conclusions drawn from the model are primarily based on logic, rather than based on experimental testing in the business world. Of necessity, such model building must be general in nature and not closely related to the conditions in any particular firm or industry, if it is to be useful. As Bromwich (1970:8) says,

> "Using models is probably the only way of progressing in academic research for they allow us to think through the consequences of changing one variable at a time, holding all others constant."

The results, it is hoped, will be generally if not specifically useful as a guide to businessmen. More importantly,the model provides a framework which can be adapted to fit the specific conditions applicable to any firm.

Limitations of the study

As might be expected from the prior discussion on the scope of the study, the list of limitations on this thesis is as long as it is important to understanding the usefulness of this work. As Cohen and Cyert (1975:18) point out, the obvious connection of a model with reality is through its assumptions. The assumptions need not be exact representations of reality, but they should be reasonable abstractions of reality. Following is a list of what is believed to be the reasonable abstractions of reality necessary to characterize the type of world to which the model is intended to apply.

1. The firm can identify meaningful strategic business units. As Allen (1978) says, each SBU should be a complete business, including all functions and its external competition should be identifiable. As Ansoff and Leontiades (1976) add, it should also have its own distinctive trends, threats and opportunities.

2. The experience curve describes cost performance over the life cycle of the SBU. Further, the experience curve is continuous and linear on a log-log scale.

3. Costs decline only through experience and not through other methods such as adopting competitive technology, buying expertise,

etc. This abstraction will be relaxed occasionally.

4. Contrary to Abernathy and Wayne (1974), managing the SBU to receive the full benefit of the experience curve does not hamper the firm's ability to accomplish rapid product innovation and improvement in product performance. In other words, if the experience curve gives benefit to the firm in one SBU, that benefit is not offset in anyway in other areas of the firm.

5. The firm can define the size and growth rate of the market for an SBU over its entire life cycle. This does not imply that the firm knows the product life cycle with certainty; but, it is able to specify its own estimates.

6. The firm understands the competition. That is, the firm knows how competitors view the product life cycle, how competitors make investment decisions, the competitors cost of capital, competitive strengths and weaknesses, etc.

7. The competitors are logical and make

rational decisions based on their own economics. That is, their objectives are simple -- to maximize net present value (NPV).

8. The world is not lumpy. Prices may be increased or decreased incrementally, i.e. pricing focal points do not exist. Investment in capacity can be added incrementally, i.e. no minimum economic size plant exists, etc.

9. There is no difference in the SBU's product between the firm and its competitors. The product can not be differentiated other than by price.

Listed above are many of the assumptions required, particularly those that the reader might appreciate at this stage. Collectively, they at best give a feel for the type of model proposed in this thesis. Other assumptions will be added as the model develops.

CHAPTER 2

REVIEW OF RELATED RESEARCH

The goals of this chapter are: (1) To show how traditional capital budgeting theory and traditional strategic planning both look at the problem of deciding which businesses the firm should support with its scarce resources to achieve the objectives of the firm.(2) To describe what needs to be done to more fully integrate capital budgeting and strategic planning. And (3) To see what assistance the relatively new portfolio matrix analysis approach is in guiding the firm in its strategic investments.

THE OBJECTIVES OF THE FIRM

Any attempt to formulate corporate strategy begins by defining the firm's objectives. The purpose of this section is two fold. First, to review a number of conflicting theories regarding the firm's objectives. Second, to select a tool, consistent with reasonable objectives, to measure the financial attractiveness of further investment in current or potential strategic business units.

The central question is what kind of objectives should the firm seek? Here we will consider four possibilities - maximum profit, maximum market value of the common stock, survival, and balanced satisfaction of stakeholders.

The historically oldest objective of the firm is unquestionably the maximization of profit, that unique measure of the efficiency of a business firm. Early on business ethics theorists, such as Anthony (1960:63-64) recognized serious problems with profit maximization as the goal of the firm. Eventhough profit is measured over an accounting cycle of at most one year, the firm generally expects to exist over many accounting cycles, in fact in perpetuity. Care must be taken that the objective of the firm has a longer horizon than one year. If short term profits are overemphasized, long term commitment of resources will be neglected and the very survival of the firm, in the long run, will be threatened. Thus the concept of profit maximization as the objective of the firm must be extended to long term, not just short term profits. Unfortunately, accounting systems are not adept at measuring the success of strategic decisions on long term profitability.

Aside from concerns about whether firms have the information necessary to maximize profit, there is considerable uncertainty as to whether they would want to if they could. As Hawkins (1973:60-61) says,

> "To say that a man maximizes profits means in practical terms that nothing - absolutely nothing - which conflicts with profits yields him any utility at all. He would sack 10,000 men and all his relatives and friends if it would make him a farthing of extra profit, even if he was already making 100 million pounds worth a year. He would work in a damp, dingy office and drive around in a second hand rubbish truck - if it helped profit by however little. He would cheat, lie and risk the lives of millions of people if only it would make his firm a few extra pennies."

Clearly, businessmen do not operate in that extreme fashion; therefore, there must be more to the objectives of the firm than pure profit maximization.

Most introductory financial texts, such as Weston and Brigham (1982), say the goal of the firm is to maximize the market value of its common stock, for the benefit of the residual owners of the firm - its common shareholders. This goal relieves some of the burden in trying to measure long run profit by accounting techniques. In theory at least, changes in the long run outlook for the firm are quickly reflected in its stock price. Also, the goal of maximizing the firm's market value ties in well with generally accepted capital budgeting techniques. That is, if the firm's value is related to the discounted value of the cash flow generated, then the capital budgeting technique of net present value advances this goal by selecting those investment proposals which yield increases in the discounted value of cash flows; hence, in theory, increasing the firm's market value.

Arguing against simple value maximization as the firm's objective are at least two considerations. First, anything Hawkins (1973) said above about maximizing profit could be said as well for maximizing the market value of the firm's common stock. Second, if firms truly attempted to maximize market value, and they believed their net present value calculations, they would accept all non-mutually exclusive investment proposals which have a net present value greater than zero. No capital rationing would exist. However, Gitman and Forrester (1977:66-71) reported that in over 50% of large business firms studied, capital rationing does in fact exist. Therefore, the goals of the firm must be broader than maximizing profits or value of its common stock.

In a sharp break with the concept of maximization, Drucker (1957:81-90) said that with respect to business objectives, "Profit maximization is the wrong concept whether it be interpreted to mean short range or long range profits." In its place he proposed "survival" as the central objective of the firm. "Adequate" profitability was but one of a set of "survival objectives" based on five "survival functions". It is interesting to note that perhaps Drucker's "survival" objective may not totally diverge from the concept of long run profit maximization in that if a firm is to maximize profits in the long run, it first must survive in the long run.

Along somewhat similar lines, Abrams (1954) developed what he called a "stakeholder theory" of objectives. In this theory the objectives of the firm should be to balance the conflicting goals of the various stakeholders: managers, employees, stockholders, customers, suppliers, creditors, government, competitors, and society in general. Dermer (1977) suggested the nature of those tradeoffs. Owners expect a reasonable growth in earning per share, dividends and market price of the common stock. Creditors expect timely payment of interest and low risk of default on principal. Customers expect a reliable source of supply and a fair price. Management and labor expect fair pay, opportunities to advance and job security. Competitors expect legal and ethical behavior by the firm. Suppliers expect timely payment for goods ordered and advance warning of changes in order pattern. Government expects adherence to its laws and a dependable source of tax revenue. Society expects the firm to be socially conscious and responsible in all its actions. In such an objective function the goals of the common stockholders need not receive special predominance.

Perhaps a more reasonable and real world approach is that taken by Ansoff (1965:42) where he assumes:

> "The firm has both economic objectives aimed at optimizing the efficiency of its total resource conversion process and social or non-economic objectives, which are the result of interaction among individual objectives of the firm's participants. In most firms the economic objectives exert the primary influence on the firms behavior and for the main body of explicit goals used by management for guidance and control of the firm. Social objectives exert a secondary modifying and constraining influence on management behavior."

Any system for selecting which businesses the firm should support and what kinds of businesses it should seek to enter must consider a multiple objective function such as that described by Abrams or Ansoff. Ijiri (1975) has suggested a quantitative approach to this problem called "goal programming". Unfortunately, this and other methods of considering conflicting stakeholder goals in the strategic problem assumes the firm can determine exactly what those goals are. Not only would goals vary among members of a class of stakeholders, and over time; but, the firm's stakeholders goals would undoubtedly change as their own stakeholders' goals changed. Obviously, the full integration of stakeholder goals into the strategic problem of the firm is very complex. Probably, it will never be solved deterministically and exactly.

Fortunately, the purpose of this thesis is not to solve quantitatively the strategic problems of the firm. Its purpose is to propose a model that will measure the financial attractiveness of investing in current or potential strategic business units. At that level of analysis, capital budgeting theory says there should not be any built in assumptions made about constrained resources. These constraints, such as the quantification of certain stakeholder goals, are validly considered only at the total firm level, not at the business unit level. To do otherwise would theoretically cause a sub-optimized solution to the strategic problem.

What is needed for the model is a measure of financial attractiveness that can be used unambiguously to compare investments in SBU's. While we must recognize that the objectives of the firm are much more complex than maximizing the market value of its common stock, the proper analytical framework for measuring the financial attractiveness of investment in an SBU is net present value. Basically, I have not addressed the complex strategic problem of determining which investments, in total, the firm should actually make. This must consider complex corporate objectives beyond NPV maximization, and solution of that problem exceeds the scope of this thesis.

The output of this work will be the NPV of further investments in SBUs. Therefore, final decisions, at the corporate level, about which SBUs will be supported may be inconsistent with NPV maximization, but at least the cost of such decisions will be quantifiable.

TRADITIONAL CORPORATE STRATEGIC PLANNING

The strategic decisions of the firm refer, according to Ansoff (1965:42), to the problem of deciding what business the firm is in and what kind of businesses it should seek to enter. It is important to recognize that in this concept the word "strategic" means "pertaining to the relationship between the firm and its environment" and not the more common usage of "strategic" signifying "important". Clearly, the selection of the firm's product/market mix is an "important" decision; but, depending on the firm's current position it may find other types of decisions, such as operating decisions or administrative decisions to be more important than strategic decisions.

Strategic decisions influence and to an extent control in turn operating and administrative decisions. Changes in strategy impose an operating structure capable of setting prices, timing output to meet demand, responding to changes in demand and changes in customer needs. These needs help determine an administrative structure and in turn set channels of authority, responsibility, and information requirements within the firm. Chandler (1962) has shown historically that as the U.S. economy developed, firms changed strategic plans. As a result, operating inadequacies developed which in turn dictated new forms of organization -- namely the modern concept of centralized policy making coupled with decentralized operating management.

A big difference, however, between strategic decisions and other types of business decisions is that the need for changes in strategy is almost never obvious. See for example Starbuck (1982). Failure to meet business objectives is often blamed on operating or administrative problems while the major problem is strategic in nature. Since strategic problems are hardest to pinpoint, they require special attention. Ansoff (1965) has developed a method of analysis which is focused on the search for strategic decision needs and opportunities.

Ansoff's method, in the tradition of microeconomics and behavioral theories, attempts to understand the nature and structure of management decisions by studying the way business firms actually operate. It does not seek to understand, as might philosophy and psychology, the decision maker's mind as he selects among strategic alternatives. The thrust of Ansoff's (1965:177) method is to:

1. Identify the problem.
2. Enumerate and define the controllable and uncontrollable variables.
3. Establish relationships among those variables.
4. Recognize important decisions.
5. Prescribe decision rules.

Complicated as corporate strategy methods may appear, remember that the end product of the firm's strategic decisions are deceptively simple -- the firm selects a combination of products and markets in which to compete.

Much can, and has, been written about corporate strategic planning. For the purposes of this thesis however, a rather short overview of Ansoff's approach will suffice. A simplified schematic diagram of the firm's strategic plan is shown in Figure 2-1.

FIGURE 2-1. THE STRATEGIC PLANNING PROCESS

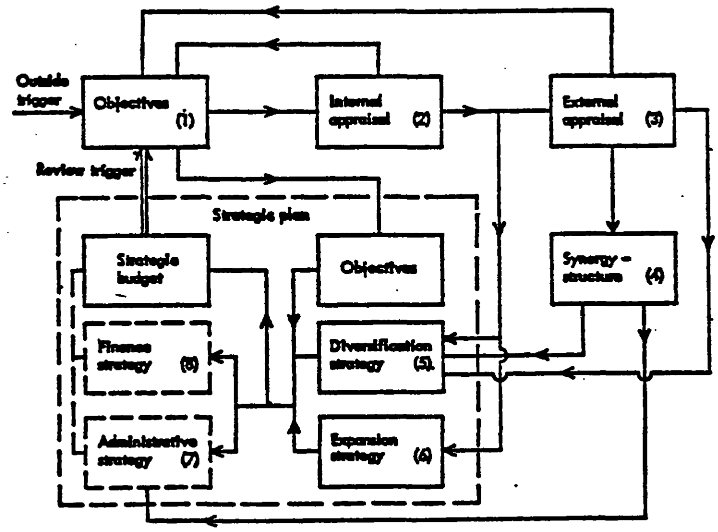

Figure 10.1. The strategic plan.

The trigger mechanism, external to the plan, is set-off in various ways primarily as a function of the firm's style and competence of management. Reactive management waits for operating results to deteriorate before attempting to solve the problem. Forward planning management anticipates future problems and take steps to offset their effects. Entrepreneurial management not only anticipates problems, but is also able to discover opportunities and take advantage of them. Since opportunities are continually available, at least to a certain degree, entrepreneurial management does not await a specific trigger, i.e. a "problem", but conducts a continual search for opportunities that may require an update of the strategic plan.

The result of the strategic plan's trigger being set off, however it occurs, is the need for a review of how the changing environment will effect the firm's objectives (1). Various philosophical approaches to defining the firm's objectives or goals have already been discussed. Ansoff's (1965:177) position regarding the firm's objectives as it effects the strategic plan in that they should be:

> "..adaptable to a variety of different management attitudes, so long as the underlying concept of the firm is that of an efficiency seeking organization which meets the objectives through the mechanism of making and selling goods and/or services."

At this stage of the strategic plan, it is important that the firm's objectives not be set as precise planning targets without further consideration of the firm's capabilities and the opportunities available to it. Notice, the plan's objectives (1) include a feedback loop resulting from a review of its internal capabilities and external opportunities.

Once tentative objectives are set, an internal appraisal (2) is conducted. Essentially it reviews the ability of the firm to meet its objectives internally through growth and expansion of its current product/market mix. The appraisal involves:

a) a review of the economic environment in which the firm currently operates, that is the potential which exists within the industry,

b) a review of the firm's strengths and weaknesses in that industry, and

c) a competitive audit, which defines the strength and weaknesses of other competitors in that industry.

As Sutton (1980) says, the firm needs to appraise those features that determine the success or failure of alternative competitive moves. Further, the main job here is to ensure that the firm can identify factors contributing to competitive success, so that they can realistically appraise their own and their competitors' strengths and weaknesses. These strengths must be assessed in terms of comparative advantages over competition in areas relevant to the product/market analyzed. As Tilles (1963) says, "Within each specific business, the real significance of a strength and weaknesses analysis is what is says about the company's competitive posture. For example, having an unparalleled manufacturing capability may not be worth very much in an industry when competition is primarily on the basis of styling and distribution. Similarly having a first-class marketing group scores no competitive points if many other people in the industry have a marketing group that is equally first class."

The result of the internal appraisal is a measure of the potential that exists within current businesses to satisfy the objectives the firm has set. If a gap exists (what Ansoff calls the "expansion" gap), the firm is faced with two options -- either reduce the objectives or seek out opportunities outside the firm's present operations. If a gap does not exist between the objective of the firm, as tentatively stated, and what current businesses can provide, the firm again is faced with two options -- either be satisfied and ignore possible diversification opportunities or raise the objectives and begin an external appraisal of opportunities. Management's choice of which way to proceed is determined in part by whether the management is a reactor, a planner or an entrepreneur.

The external appraisal (3) is meant to find and analyze diversification opportunities open to the firm. Ansoff (1965:178) believes that,

> "..because of partial ignorance, external appraisal does not attempt to deal with individual firms and products...The outcome of external appraisal is a series of lists of industries ranked in the order of their potential for closing the diversification gap and a definitive management decision on whether the firm will diversify."

Before any diversification strategy can be selected the firm must decide to what extent, if any, it will vary its administrative structure to take advantage of synergy potential (4). Synergy value and changes in administrative structure must be considered concurrently in the external appraisal since they may well affect the final ranking of industries as aids in closing what Ansoff calls the "diversification" gap.

The next step is to assemble several product/market portfolios which are feasible for the firm, based on its available resources. Finally, management must make a decision on the "best" portfolio based on the firm's objectives, the inherent risk and uncertainty of the analysis, all in an environment of at least partial ignorance of both the opportunities and the threats associated with each portfolio. This process proceeds in parallel for both the diversification (5) and the expansion (6) substrategy and is then combined to produce the total strategy for the firm.

A selection of a preferred product/market portfolio will have profound influences on the firm. Both an administrative strategy (7) and a financial strategy (8) must be developed before the firm can begin implementation. The administrative strategy will include rules for the organizational evolution of the firm and will be further specified to include specific organizational relationships and for resource growth such as management development plans. The financial strategy will include rules governing how the firm will finance its growth such as specified debt to equity and earnings retention ratios. Clearly, such strategies are not simple derivatives of the selected product/market portfolio. They are both influenced by the selection and in turn influence the selection process. For example, financial limitations tend to set overall limits on strategic activity.

Finally, the respective strategies combined with the firm's objectives are used to produce a strategic budget. The strategic budget is a document which will systematically organize the effort to implement the decision made about the preferred product/market portfolio. A description of the strategic budget is based on Drucker's (1959:238-239) definition of business planning as:

> "..a continuous process of making present entrepreneurial decisions systematically and with the best possible knowledge of their futurity, organizing systematically the effort needed to carry out these decisions and measuring the results of these decisions against expectations through organized systematic feedback."

An adequate strategic budget must consist of a performance budget, which defines the actions to be taken along with the expected results, expressed in pro forma financial terms; and a resource budget, which defines the amount and timing of resource commitment in support of the performance budget.

The general framework of the strategic plan would look as shown in Figure 2-2 on the next page. The strategic plan, with responsibility resting at the highest level of the firm, decides upon and allocates resources to the strategic business units selected by the firm. This is further described in three component plans.

FIGURE 2-2. FRAMEWORK OF THE STRATEGIC PLAN

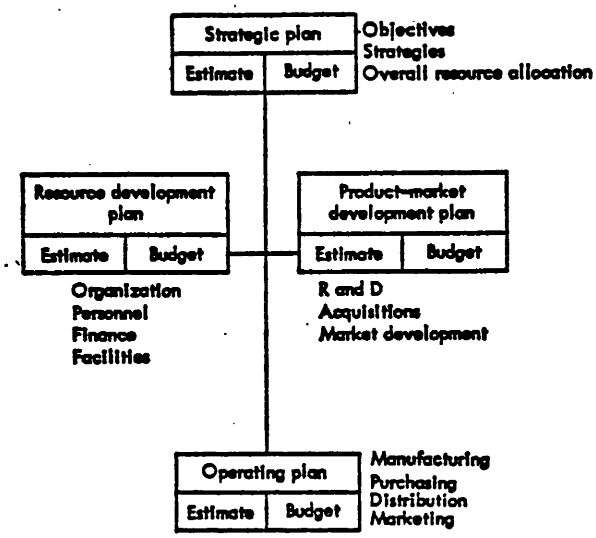

Figure 10.3. Generic structure of plans.

The product/market development plan details implementation of changes required in the products/markets of the firm and defines such activities as acquisitions, product/market development and research and development efforts. The resource development plan details the structure and acquisition of resources including organizational changes, personnel planning, finance and facilities planning. The operating plan details the day-to-day operation of the firm, and includes the traditional functions of purchasing, manufacturing, marketing and distribution.

As a quick summary, let's review Day's (1975) description of the specifics of the strategic planning process:

1) State the mission of the strategic business unit (SBU).

2) State the desired future position of the SBU that the firm wants to attain.

3) Review key environmental assumptions and threats and opportunities.

4) State the strengths, weaknesses and problems of the SBU and its major competitors.

5) Calculate the strategic gap between the desired and forecast position of the SBU.

6) Decide the actions to be taken to close the gap -- the strategy.

7) Plan for obtaining the resources required for implementation.

To define the strategic planning process is not to prove that is it necessary to the firm. Ansoff (1965:101) addresses this point by first examining the alternative to strategic planning. That alternative is basically to have no rules beyond the simple decision to look for attractive investments. Several reasons favor this approach. Substantial resources, primarily executive talent, could be reallocated in the firm if strategic planning were discontinued. The field of potential opportunities would be completely unrestricted -- strategic planning somewhat limits the scope of the search. Since strategy is based on incomplete knowledge, some attractive opportunities will be missed -- but delaying resource commitment until an opportunity is well defined, the firm is able to act on the best possible information.

In favor of corporate strategic planning, the following arguments can be made. Without a strategy, no rules guide the search for new opportunities. Both research and development internally and acquisition work externally lack focus and can only either await opportunities or use a shotgun approach, both inefficient. Investment decisions will likely be of poorer quality, due to a lack of understanding of unfamiliar businesses. With no formal provision for dealing with partial ignorance, the firm will be unable to judge whether a particular opportunity is a rare one which demands action. There is a danger of premature resource commitment or perhaps undercommitment. Without benefits of strategic reappraisals, the firm may commit resources to SBU's that should not receive support.

To recap, the advantages of not missing opportunities with an unlimited search scope, not committing resources until opportunities are well defined, and conserving executive talent must be weighed against the disadvantages of inefficient search, poorer decision quality and a lessening of control over resource allocation. It would seem that for most firms, particularly fully integrated operating companies, the advantages of strategic planning will outweigh those of total flexibility.

However, as reported by Lorenz (1982), criticism of traditional strategic planning has developed. At a recent conference on exploring the strategy-making process, sponsored by the Strategic Management Society, Mintzberg claimed that complex planning processes are not always needed, and that a company does not need to reassess its strategy each year as part of a planning cycle. More important than formal strategy, Mintzberg said, is the entrepreneurial ability to respond to sudden environmental changes. At the same conference, Runett argued that a strategy was important only when the firm stands the chance of gaining a sustainable competitive advantage over its rivals. In most industries, he claimed, the status of firms is impossible to alter and as a result most strategic planning is wasted.

Naturally, as with most everything, controversy swirls and formal strategic planning's final place as a business tool is unsettled. It does appear, however, that the increasing use of corporate planning groups by corporations over the last decade favors Ansoff's argument, that on balance it is useful.

TRADITIONAL CAPITAL BUDGETING THEORY

SIMILARITIES AND CONTRASTS TO STRATEGIC PLANNING

At first glance, strategic planning, defined by Ansoff (1965:18) as "the problem of deciding what business the firm is in and what kinds of businesses it will seek to enter", closely resembles the capital budgeting decision. The purpose of this section is to describe in some detail the present state of the art in capital budgeting theory, and to see how well it helps the firm solve its strategic problems.

Capital budgeting theory

Johnson (1971:149) defines capital budgeting as the evaluation of capital expenditures whose principal benefits are realized over a period longer than a year. He recognizes the distinction from operating expenditures is arbitrary, because in both cases the firm spends its money in the hope it will realize some return on its investment. Why then the concentration in finance on analyzing capital expenditures over operating expenditures if conceptually there is really no difference? Johnson (1971) points out three basic reasons. Capital expenditures are often of considerable size relative to the firms resources. Capital expenditures represent long-term commitments of funds, which cannot be quickly and/or cheaply reversed. Capital expenditures, which may take the firm into new businesses with significantly different risk characteristics, require additional analysis not deemed necessary when analyzing operating expenditures. Finally, since the benefit of capital expenditures are spread into the future, discounted cash flow techniques, a concept relatively new to the business world*, are required for

*For example, Solomon (1967) reports that as recently as 1949 only 2% of a sample of U.S. companies used discounted cash flow techniques to analyze capital expenditures.

proper analysis.

A discussion of capital budgeting theory must begin with a decision of the goal of the firm. The goal used by essentially all writers in capital budgeting is the maximization of the market value of the firm's common stock. Therefore, if the firm's market value is related to its future cash flow, the way to maximize the firm's market value is to select those projects with the highest net cash flows, time value of money considered. Basically then, the capital investment decision boils down to determining the proper cash flows and proper discount rate for each potential investment proposal, and setting selection rules. Early in this century, Fisher (1907) proposed exactly that path. Current theorists, such as Merrett and Sykes (1963), still follow it.

It is now generally accepted in the literature that capital budgeting decisions should be based on the additional net cash flows generated by an investment proposal. As Bierman and Smidt (1980:127) point out:

> "Every investment analysis involves a comparison of alternatives. If there are not at least two possibilities there is no problem of choice...because the investment analysis involves a comparison of two or more alternatives, it is not surprising to find that any estimate of cash flows must also be on a comparative basis."

Cash flows that are developed for a particular investment proposal that seems to stand alone without the need for comparison, such as those for starting a new business, are called absolute cash flows. The analysis of projects with absolute cash flows, using net present value, implicitly compares the investment to an investment that would yield a return equal to the cost of capital indefinitely for each net outlay.

Bromwich (1970:8) says that the most important question to ask when determining relevant cash flows is, "What difference does the decision make?" Two specific examples of costs will be used to illustrate relevant costs. Cost accounting correctly allocates a share of costs like administrative expense to all operations based on some reasonable yet arbitrary method like allocation based on sales. Such costs are not relevant to the proposal unless its adoption would actually increase administrative expense by the amount allocated by cost accounting. The rule to follow is that expenses that would be incurred by the firm whether or not the investment is accepted are not relevant to the investment decision. In some cases an investment proposal may require the use of some scarce resource available to the firm for which the current cash outlay may be nonexistent or may understate the value of the resource to the firm. An example would be a project which would use existing floor space in a plant already owned by the firm. Cost accounting would allocate to the project a share of the depreciation of the plant based on historical cost. The proper cost to the project, called the opportunity cost, is the estimate of how much the resource would earn, say by renting out the idle space, if the project were rejected.

The second major step in the capital budgeting decision is determining the proper discount rate for each investment proposal. A direct attack on the problem of the definition and measurement of this cost of capital is only about a generation old -- see Solomon (1956). Over that period, the concept has been one of the most controversial in finance. Generally, the cost of capital is assumed to combine both the concepts of the time value of money and expected risk. Bierman and Smidt (1980: 258-259, 263) argue against their dual inclusion and suggest using a default free interest rate as the discount rate with risk adjustments made separately. Modigliani and Miller (1958) even challenge the concept of an optimum capital structure and therefore a minimum cost of capital.

Fortunately, the model proposed in this thesis doesn't require the solution of these and other problems related to the cost of capital. The main contribution of the model is in the area of incremental cash flows attributable to investments in SBU's. Its practical usefulness is limited by the correctness of the discount rate used on those cash flows.

The final step in capital budgeting theory is the decision rules to follow based on the discounted incremental cash flows of the investment proposal. Using net present value the decision rules are straight forward, assuming no resource constraints. If a project is independent, it should be accepted if the net present value to the firm is greater than zero. If a project is mutually exclusive with one or more alternatives, the project with the highest net present value should be selected, assuming its net present value is greater than zero. The logic of those selection rules supports the goal of increasing the market value of the firm's common stock.

Relationship to strategic planning

On the surface, the procedure described in capital budgeting theory appears applicable to strategic planning, that is selecting what products to develop and what markets to enter. Beranek (1963) extends capital budgeting theory to the entire spectrum of corporate investment decision, including the strategic. Where, if at all, do product/market investments differ from plant and equipment investments?

Simon (1960) has shown that the decision process has four steps:

1. Perception of the opportunity or need.

2. Formulation of alternative courses of action.

3. Evaluation of the alternatives.

4. Choice of alternative(s) for implementation.

Capital budgeting theory concerns itself with the last two steps. The others area assumed to take place before and external to the analysis.

Ansoff (1965:27-32) sees these deficiencies and others as severely limiting. Strategic planning requires a method for continuing intelligence and for the diagnosis of need for new strategies. All this must take place before opportunities are sought and analyzed. Strategic decisions are characterized by conditions of partial ignorance about opportunities. Capital budgeting theory on the other hand assumes that all investment alternatives are known, even down to the point of describing cash flows. Practical strategic planning must broaden capital budgeting to include provisions for search and evaluation of projects under partial ignorance. Capital budgeting theory uses net present value, and indirectly market value of the common stock, as the measure of a project's worth. Many writers have pointed out the need for a multiple objective function of the firm, see for instance Dermer (1977). Also important, as Ansoff (1965:28) says:

"...Limitations of data usually lead to cash flows which are typical of a product-market area, not one that are specific for the opportunities in question. However, what the firm needs is not typical but <u>particular*</u> flows which will reflect the unique competitive advantages of the product market opportunity..."

While capital budgeting theory implicitly requires such effects be taken into account, it provides no method for doing so.

Ansoff (1965) has developed what he calls a "checklist" of shortcomings in capital budgeting theory that must be corrected in a strategic decision model, as follows:

1. Include all four, rather than the last two steps in the generalized problem-solving sequence (as listed earlier in this section). Emphasis should be on the first two steps, monitoring the environment for changes and searching for attractive product opportunities.

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*Emphasis is Ansoff's.

2. Handle allocation of the firm's resources between opportunities in hand and probable future opportunities under conditions of partial ignorance.

3. Evaluate joint effects (synergy) resulting from addition of new product-markets to the firm.

4. Single out opportunities with outstanding competitive advantages.

5. Handle a vector of potentially antagonistic objectives.

6. Evaluate the long-term potential of projects eventhough cash flow projections are unreliable.

The model proposed in this thesis will assist in integrating capital budgeting and strategic planning by:

1. Aiding in the search for attractive product opportunities by defining which kinds of product/market opportunities are potentially profitable for the firm.

(Ansoff"s Checklist #1)

2. Aiding the evaluation of joint effects (synergy) by including experience curve effects. (Ansoff's Checklist #3)

3. Aiding in identifying opportunities with outstanding competitive advantages by defining which kinds of opportunities are potentially most profitable for the firm. (Ansoff's Checklist #4)

4. Improving the reliability of long-run cash flow projections by proposing a system to "manage" the competitive environment of those projects selected by the firm. (Ansoff's checklist #6)

PORTFOLIO MATRIX ANALYSIS

What seems to be lacking in the traditional strategic planning process is, as Day (1975:4) points out, "a systematic procedure for generating and choosing strategic alternatives." Portfolio matrix analysis, in its many forms, is a recent attempt, as Henderson (1979) says, to move strategy development from an intuitive art toward something closer to a logical, explicit and orderly analysis. The purpose of this section is to look at a number of the most important portfolio matrix schemes and to see what, if any, help they are to the firm in selecting which businesses it should invest in.

First, the idea that a firm should have a portfolio of businesses rather than a single business needs to be addressed, particularly in the light of much work denying the benefits of diversification. For example, Pogue and Lall (1974:20) contend that:

> "No gain in aggregate market value (from acquiring firms) can be anticipated...the market value of the new firm will simply equal the sum of values of the component firms. Corporate diversification, while often attractive to corporate management, may lead to no benefits to the stockholders (assuming away synergy or undervalued companies). The shareholder can easily achieve any desired degree of portfolio diversification by selecting a portfolio of securities he feels to

be appropriate. Additionally, corporate diversification reduces the number of diversification options open to investors and may lead to a reduction rather than an increase in aggregate market price."

Henderson (1979:80), however, points out that without mergers growing firms must always be self-financed either through retained earnings or from public capital markets. If a firm's current profits are not in proportion to its growth potential then it is likely that growth must be restrained to match financial resources available. The conglomerate* however is exceedingly well positioned to direct capital investment into the most productive areas. It can be more efficient and effective than public capital markets are ever likely to be, for two important reasons.

First, top management of even a very diverse firm is better equipped than an outside investor to judge the potential of a growing business. Such a firm has access

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*"Conglomerate" is Henderson's word choice to describe a firm with many diverse businesses linked by common financial resources. Companies not traditionally thought of as conglomerates such as DuPont, with synthetic fibers as well as auto paint, qualifies as does General Electric with light bulbs as well as engineering plastics.

to product, market and competitive data that even the most detailed prospectus cannot provide to the general public. Further, the firm has management and staff data analysis skills that are likely to be superior to that of any individual.

Second, in a world of high corporate and individual tax rates, particularly with taxation of dividends, the ability to include in one tax paying entity both quickly growing businesses, which are likely to report accounting losses, along with mature businesses, which are likely to report profits, has a large cost advantage. Income taxes, in the U.S. for example, will take away about half of reinvestable funds, if reported as profit. If the remainder is paid out in dividends and taxed at individual rates, only a fraction will be left for eventual reinvestment. As a consequence, if the firm is able to treat these reinvestment expenditures as an expense offsetting profits elsewhere in the firm, as "conglomerates" do, then it has a great advantage in terms of its cost capital. Further, as Weston and Brigham (1982:391) point out,

> "The cost of new common stock or external equity capital is higher than the cost of retained earnings because of flotation costs involved in selling new common stock."

In conclusion, the conglomerate is in an unexcelled position to obtain capital at the lowest possible cost and to put it to the best possible use. Therefore, it is to the firm's advantage to have a stable of businesses to balance cash flows within the corporation. As Day (1975:9) says,

> "Some products should generate cash (and provide acceptable reported profits) and others should use cash to support growth; otherwise the company will build up unproductive cash reserves or go bankrupt."*

The achievement of this balance is the art of portfolio management.

As mentioned earlier, portfolio matrix analysis has taken many forms. We will review six of the best known: (1) the Boston Consulting Group's Share-Growth Matrix, (2) McKinsey and Company's Business Strength-Industry Attractiveness Matrix, (3) the Shell Directional Policy Matrix, (4) Sutton's Strategic Planning Matrix, (5)

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*Day does point out in a footnote that changing debt or dividend policies could increase growth or delay bankruptcy, assuming as he does that for most companies, the likelihood of new equity funding is limited.

the PIMS approach to portfolio planning, and (6) Rothschild's Financial Ratio Matrix. Much of the work reviewed is taken from Channon and Jalland's (1979) summary of strategic portfolio planning systems.

Share-growth matrix*

Early on, the Boston Consulting Group recognized two primary determinants of a business' ability to generate cash -- relative market share and market growth rate. High share businesses, with at least some monopoly power and likely economies of scale, should generate substantial operating cash flow. High growth rate businesses should consume substantial amounts of cash to finance fixed asset and working capital requirements. The interplay of these two variables gives rise to the familiar growth-share matrix as shown in Figure 2-3, on the next page.

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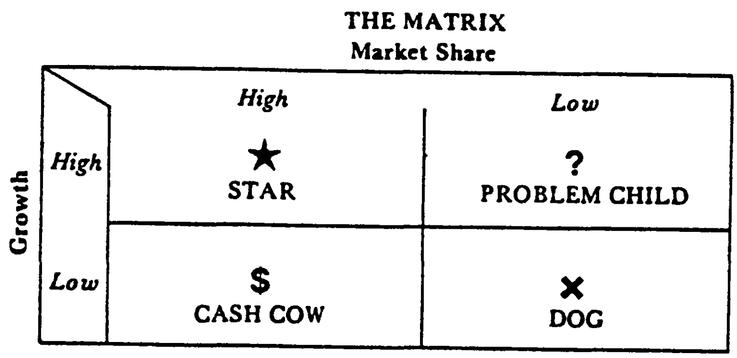
*Among Boston Consulting Group publications that describe the portfolio are Perspectives on Experience (1970), The Product Portfolio (1970), Cash Traps (1972), and The Experience Curve Reviewed: The Growth Share Matrix of the Product Portfolio (1973).

FIGURE 2-3. THE GROWTH-SHARE MATRIX



"Stars", in the upper left quadrant are both high share and high growth businesses. They require significant investment to maintain growth, but due to their high market dominance they should also generate large operating cash flows. "Stars" tend to be in rough equilibrium in terms of cash flow. "Cash Cows" tend to be former stars whose market has matured and become low or no growth. Opportunities for profitable reinvestment are not sufficient to absorb the cash generated by operations; hence "cash cows" are the principal source of the firms internally generated investment funds.

"Question marks" (or as Henderson calls them, 'problem children') are the firm's low share entries in high growth businesses. They require large investments to maintain share but have poor operating cash generation prospects. The result is a large negative cash flow. Usually, the firm can adequately support only a few such businesses. Again because of large negative cash flows, a decision must be reached early about which such businesses will be supported and which divested or abandoned. Recognize, that to support adequately a problem child, the firm must invest to buy market share; otherwise, it will become a "dog" as its market matures.

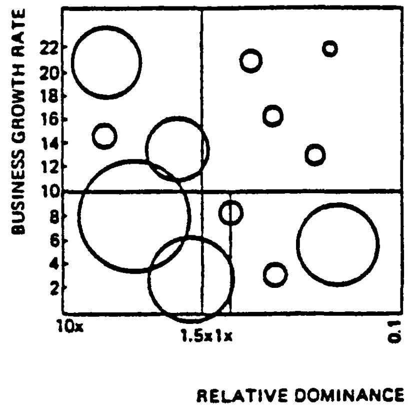
Businesses with low market share and slow growth are "dogs". They probably show an accounting loss due to a poor relative cost structure and still require some investment support to sustain even the slow growth. Many such businesses tend to become cash traps, perpetually absorbing cash. The business is a drag, except perhaps in liquidation.

As Henderson (1979:166) says,

> "The need for a portfolio of businesses becomes obvious. Every company needs products in which to invest cash. Every company needs products that generate cash. And every product should eventually be a cash generator; otherwise, it is worthless."

The goal, according to BCG, is to achieve a balance in the firm's business portfolio, taking cash generated by "cash cows", the liquidation of "dogs" and the divestment of some "questions marks" and using it to support the "stars" and certain fledgling growth businesses. One way to achieve such a balance is to plot on the share-growth matrix the location of each business in the firm's portfolio as shown in Figure 2-4.

FIGURE 2-4. PORTRAYING SBU's ON THE SHARE GROWTH MATRIX



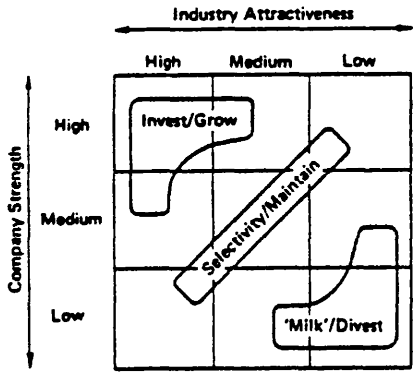
The size of each business, based on sales, assets or cash flow is proportional to the area of the circle used to define the business' location on the matrix. Conclusions can then be stated regarding the overall balance and the adequacy of internal funds to support growth prospects.

Business strength-industry attractiveness matrix

The familiar, and highly qualitative, McKinsey matrix is shown in Figure 2-5 on the next page. It is the result of early work at General Electric, which subdivided its activities into strategic business units and positioned them on a three by three matrix measuring business strength and industry attractiveness. McKinsey's approach recognizes that other factors beside share and growth play an important part in corporate strategic planning.

FIGURE 2-5. THE McKINSEY MATRIX

Basic strategy varies with different assessments
of industry attractiveness and company strengths....



....and different basic strategies imply differing
objectives and elements of strategy....

Basic Strategic Intention	Invest/Grow	Selectivity/Maintain	'Milk'/Divest
Primary Objective	Build market position for long-term profit	High short-term profits, medium cash flow	Maximize cash generation
Elements of Strategy Investment	Maximum digestible	Selective/high return segments	Minimum/dispose opportunistically
Risk	Accept/contain	Limit	Avoid
Share	Build/diversify markets	Target growth/protect position	Forego share for profit
Pricing	Lead, exploit cost/value elasticity	Stabilize for maximum contribution	Lag, even at expense of volume
Products	Lead, diversify	Differentiate • Specialization • End-users • Performance	Prune
Costs	Utilize scale, not thrift	Aggressive reduction of variable, economize on fixed	'Variabilize' by ruthless cutting, consolidation
Marketing	Build creativity, coverage	Cut creativity, keep coverage	Cut
Management	Entrepreneurs	Sceptical, balanced	Disciplined - strong cost control

According to McKinsey (1978) the industry attractiveness is determined by the size of the market, the growth rate, the degree of market segmentation, the competitive structure, the profitability, technical inputs required and environmental factors such as social implications, legal considerations and human relations. The firm's business strengths are determined by market share and product strengths, its image among customers and competitors, its technological competence, its financial and human resources, its risk preferences and its commitment factor to the business, which is a function of how closely this business fits the strategic mission of the firm.

Clearly, this system as advocated incorporates both quantitative and qualitative variables and allows cross-impact relationships to be considered. Strong criticism of McKinsey's approach is primarily directed at the model's vagueness; that is, the axes can mean whatever any user wants them to mean. As Channon and Jalland (1979) say:

> "In reality this (matrix) is not practicable...(because) there is no specific weighting system for the variables on which data is collected. As a result the positioning of a business within the matrix is much less precise than with the Boston approach where both the main variables are quantifiable."

Many see McKinsey's approach as a tool for debating strategic resource allocation, even if it is not precisely quantifiable. If the market attractiveness is defined as being that expected over the next five to ten years and business strength being the firm's current position, which could potentially be changed by investment, then the focus becomes one of managing movement around the matrix.

Directional policy matrix

A fairly simple-minded attempt to overcome the McKinsey problem of locating the position of a business on the product portfolio matrix is the Directional Policy Matrix developed by Royal Dutch Shell (1976). Similar to the McKinsey matrix, the Directional Policy Matrix is a three by three matrix with the axes measuring "competitive capability" and "prospects for sector profitability". Again the two dimensions are composed of multifactor variables, the composition of which can vary among firms. Each variable is assigned a score* from zero to four with zero being "poor" and four being "excellent".

Shell has defined "competitive capability" on the basis of three factors: market position, production capability, and product research and development. Thus a

*Actually, Shell itself uses "stars" instead of numbers for increased "visual impact"; i.e. a score of two would for Shell become three "stars". (One star translates to a score of zero.)

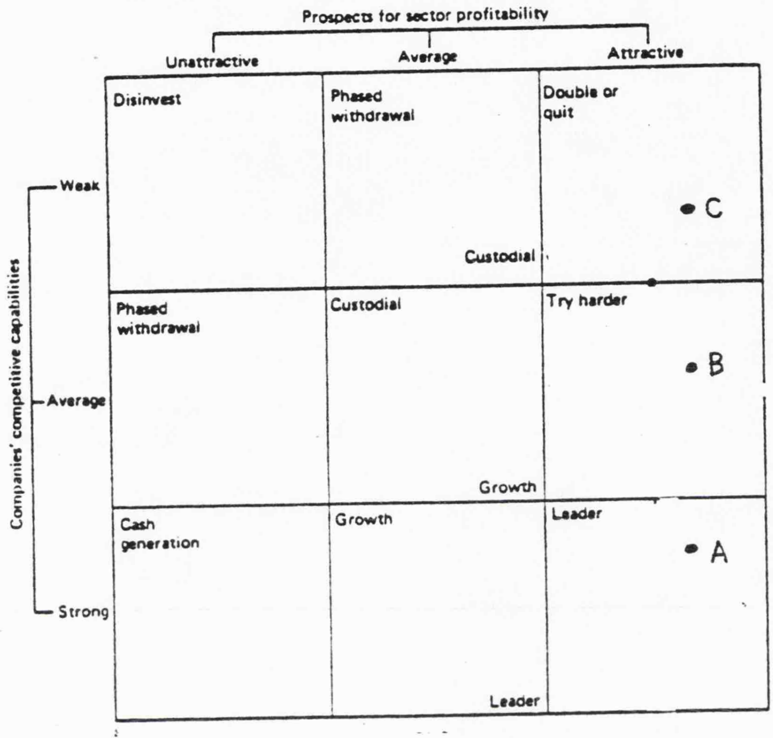
five "star" rating would apply to a business with Shell having a high relative market share, sufficient and modern production facilities, and technical leadership. Conversely, a one "star" rating would signify a minor current position in the business.

The Directional Policy Matrix, as used by Shell, defines the "prospects for sector profitability" on the basis of four factors: market growth rate, market quality, industry feedstock position and environmental aspects. In another industry, says insurance, industry feedstock position and environmental aspects would be replaced by more meaningful factors, say level of training of agents and flexibility of insurance regulators.

Other competitors would be similarly analyzed with weighting factors applied if desired, and the final result plotted on the matrix as shown in Figure 2-6, on the next page.

From these relative positions alternative strategies emerge. Competitor A, in a leadership position equates approximately with a Boston Consulting Group (BCG) matrix "star". Competitor C, in the double or quit zone closely conforms with the BCG "question mark". Competitor B, in

FIGURE 2-6 THE DIRECTIONAL POLICY MATRIX



the try harder position implies that the SBU, while no longer a BCG "question mark" must be allocated sufficient resources if it is to move toward a leadership position.

The Directional Policy Matrix incorporates a richer mixture of quantitative and qualitative variables in assessing portfolio positions than does the BCG approach. Further, a three by three matrix reduces the sharpness of the BCG matrix positions. Criticisms of the Directional Policy Matrix are obvious. Is a two "star" rating really twice as good as a one "star" rating? And, on what logical basis are the various factors weighted to give a final score?

Strategic planning matrix

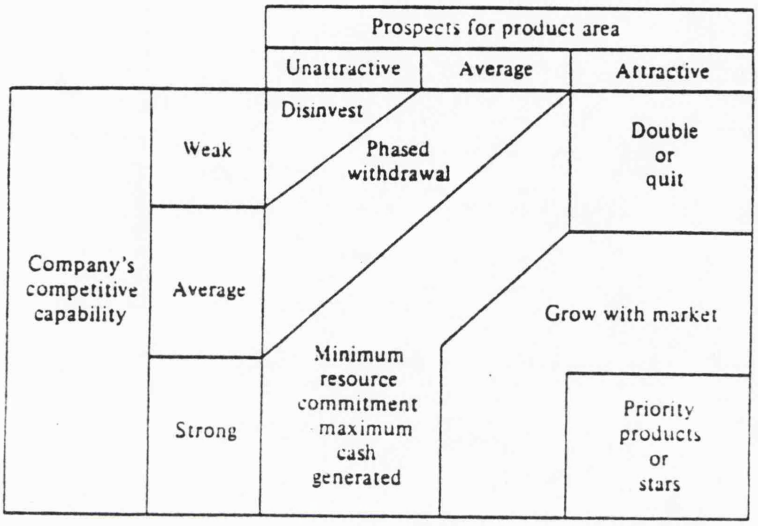
Sutton (1980:83-85) has developed what he calls the Strategic Planning Matrix based on Shell's Directional Policy Matrix. Different from the others, though he explicitly recognizes that:

> "The matrix...assists the classification of individual product areas, but on its own, this is not sufficient to determine the firm's strategic portfolio. The strategy must also consider the effect of interactions between different areas, and in particular it should consider the effects of instability and uncertainty."

The Strategic Planning Matrix is also a three by three matrix with the axes measuring "competitive capability" and "general performance prospects". According to Sutton (1980:84), general performance prospects are predictable from the structure of the market; and the firm's ability to share in that section's growth or profitability is determined by the firm's present competitive strengths in that product area. No mention is made of what determines the structure of the market or the firm's competitive capability.

An example of the Strategic Planning Matrix is shown in Figure 2-7, on the next page.

FIGURE 2-7. THE STRATEGIC PLANNING MATRIX



Priority products combine a strong competitive position with generally attractive prospects. Conversely, the combination of a weak competitive position with an unattractive market identifies areas ripe for immediate divestment or phased withdrawal. A weak competitive position in an attractive market calls for a double or quit strategy. Finally, the remaining areas, the "grow with market" and "minimum resource commitment - maximum cash generated" areas may have a variable dividing line depending on the resources available after the priority needs have been met.

Profit impact of market strategy (PIMS)

An interesting attempt to define what conditions make a business successful is the PIMS study. I have included a short discussion of it here eventhough it is not a portfolio matrix analysis because its findings lend support for the logic of many matrices. Also, it relates quite closely to the model proposed in this thesis in that it considers the impact of market share, growth, competitive environment, etc. on financial results. Conclusions drawn by this work from theory must not contradict what PIMS finds empirically.

Buzzell, Gale and Sultan (1975) describe PIMS as a major data base containing key details of the operating characteristics of a wide variety of different businesses. From this data a series of cross-sectional multiple regressions models have been developed and refined to attempt to discover the "laws of the market place". There is a special attraction to the PIMS model. As Murphy (1983:178) says:

> "There is a limit to what any of us can learn from experience. We run out of money to pay for our mistakes. We run out of lifespan to profit from the wisdom those mistakes give us...Learning from PIMS is almost as useful as, and a good deal less painful than, learning from experience."

There are two basic PIMS models. The oldest and the best in terms of predictive ability is the PIMS Par ROI model which measures financial performance in terms of pre-tax returns on investment. The other, the PIMS Par Cash Flow model was developed as a result of the high interest rates of the 1970's and hence corporate interest in liquidity and cash flow.

Without invading the workings of the model lets review some useful generalities from it:

* "Doing the right thing is much more important than doing it well. Being in the right business in the right way is 80% of the story; operating that business in a skillful or lucky way is 20%.." Murphy (1983:178)

* Businesses that produce a high value added per employee are more profitable.

* Large market share, relative to the three biggest competitors, enhances profits and cash flow.

* High quality products, as viewed by the customer, enhances financial performance.

* The financial result of innovative R & D and increased marketing effort is heavily determined by initial position in the market. Those who start from a weak position in the marketplace usually fail to benefit from

innovation.

* Vertical integration is a good strategy if the market is mature and stable. It is a bad strategy when markets are growing or declining rapidly.

* Growth, either from market growth or a strategy of increasing market share, tends to increase profit but decrease cash flow.

* Product characteristics do not effect financial performance. "...It doesn't matter if the product is edible or toxic, large or small,... Two businesses making entirely different products but having the same investment intensity, productivity, market position, etc. usually show similar operating results." Murphy (1983:178)

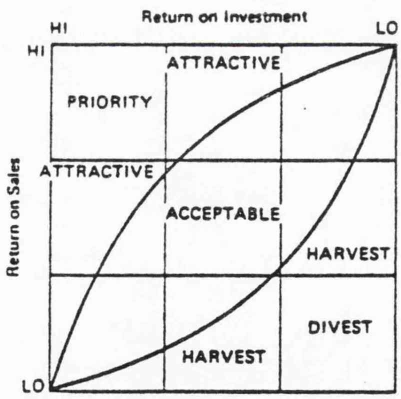
* "Most clear strategy signals are robust." Usually a favorable strategic move will have a large cost/benefit surplus. Moderate size forecasting error should not change the decision and invalidate the strategy. Murphy (1983:178)

Clearly, for any firm, understanding the impact of the underlying dynamics of the businesses in its portfolio in terms of both pretax return and cash flow is useful. Further, PIMS also incorporates a strategy sensitivity and optimization model which permits alternative strategies to be assessed under varying environmental conditions.

Financial ratio matrix

Finally, Rothschild (1976:179) has put together a Financial Ratio Matrix, based on PIMS results and shown in Figure 2-8.

FIGURE 2-8. THE FINANCIAL RATIO MATRIX

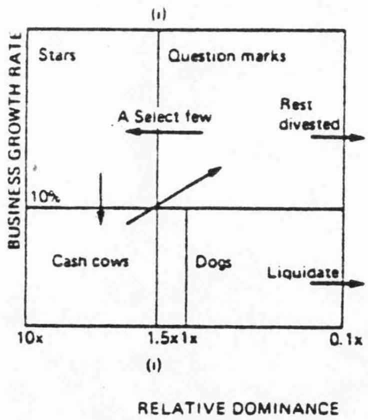


The matrix's axes measure return on sales and return on investment. Those businesses which are to receive priority tend to do well in both dimensions. Businesses doing poorly in both dimensions tend to be candidates for divestment. This matrix particularly seems simple-minded. clearly, return on investment is more important than return on sales since margins are a function of the type of business and generally are related to asset turnover.

Usefulness of portfolio matrix analysis

Early on in this chapter, I suggested that one of its goals was to see what, if any, help the various portfolio matrix schemes were in selecting which businesses the firm should support. As a format for discussion, consider in detail only the capital investment implications of the Boston Consulting Group's Share-Growth Matrix, although all other matrices have similar investment implications.

FIGURE 2-9. BCG's GROWTH-SHARE MATRIX

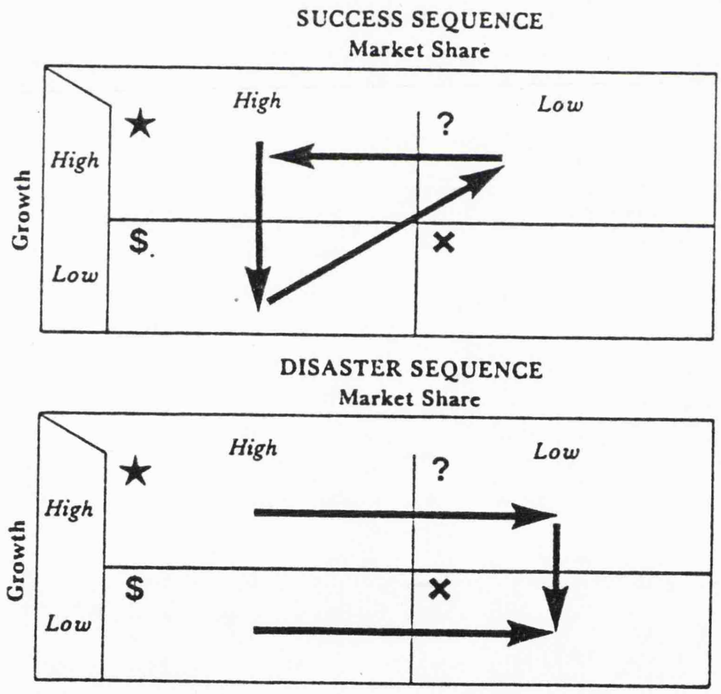


Again, the general rules are that "stars" should be priority investments, "cash cows" are expected to throw off sufficient quantities of cash to finance "stars" and support market share expansion by at least some "question marks". "Dogs", as Henderson (1979:166) says:

"...are not necessary. They are the evidence of failure either to obtain a leadership position during the growth phase, or to get out and cut losses."

Examples of movement within the matrix that yield strategic success and disaster are shown in Figure 2-10.

FIGURE 2-10. STRATEGIC SUCCESS AND STRATEGIC DISASTER



The rules seem clear and even logical at first glance, but as Lorenz (1982) reports:

"The danger of BCG's labels is that in

> themselves they convey simplistic policy prescriptions...BCG's own consultants do not use them in a simplistic manner, but the fact remains that large numbers of businessmen did just that..."

As an example of the simplistic investment implications of the portfolio matrices, lets consider "stars"; probably the least controversial with respect to investment priorities.

Clearly "stars", if everything goes right, have a very high value to the firm. By definition, the market share battle has been won and the product is still early in its life cycle. In financial terms, the net present value of the remaining time left in the product life cycle is high because much of the investment in assets and in acquiring market share has already been made. The big payoff in cash flow yet remains to be realized. Does it naturally follow that further cash investment in this "star" will necessarily yield high net present value? As always, net present value must be calculated from incremental cash flows -- in this case what the business' future cash flows will be if the firm invests versus not investing. That incremental cash flow will be heavily dependent on competitive actions.

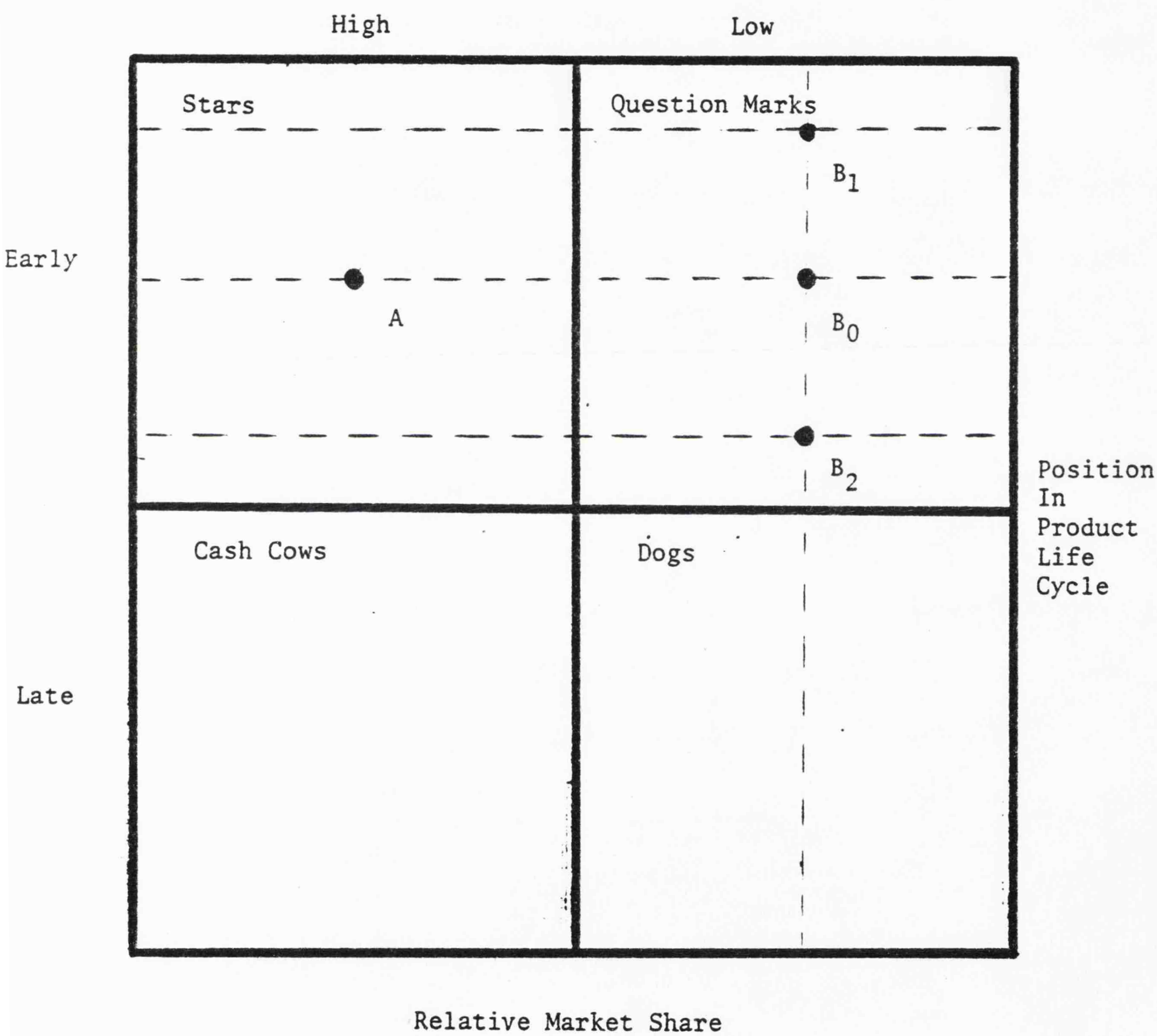
Assume a simple competitive environment with only two players, the firm (A) and a competitor (B), and allow the transformation of the BCG's "growth" axis into position in the product's life cycle. Figure 2-11, on the next page, shows the position on the matrix of the firm at A and therefore the firm's estimate of the competitor's position at B_0. Two alternate positions for the competitor are also shown depending on how he views the product. Note, there can be no argument about the current relative market share, and therefore the relative cost position if the experience curve effect is in force. But reasonable men can differ on the position in the product life cycle, primarily based on their ability to understand the market. At B_1, the competitor believes it is very early in the life cycle. At B_2, he believes it is much later, even later than the firm suspects.

Will the competitor's response vary depending on whether he views his position as being B_1 or B_2? Likely so -- the competitor is much more apt to select the business for further support if it believes the business is located at B_1 instead of B_2. As previously discussed, the way a firm moves a "question mark" product toward becoming a "star" is to invest in market share. Generally, a competitor selecting one of his "question marks" to challenge this firm's "star" will result in lower prices and/or higher costs and therefore lower earnings and cash flow for the "star".

Logically, there are basically two extremes in incremental cash flow that the firm can expect from further investment in its "star". They depend primarily

FIGURE 2-11.

COMPETITOR'S EFFECT ON INVESTMENT ATTRACTIVENESS



on whether and to what extent the competitor desires to increase share. Let's look in more detail at those two extremes.

The firm's present value of further investments in its "star" business, given the competitor thinks that his position is at B_1, is very high. A look at the firm's incremental cash flow position for investing versus not will show why. If the firm invests, it will likely maintain share and therefore volume; and if the "experience curve" effect is in operation, it will also maintain a cost advantage over its competition. If it fails to invest, and the competitor does as he is likely to do, the firm will lose share and volume, and the cost advantage will deteriorate. The difference between those two scenarios is likely to produce large incremental cash flows and therefore a large present value for further investment in the "star" business.

Conversely, the present value of further investment by the firm, given the competitor thinks that his position is at B_2 is not nearly so high. Again, an incremental cash flow analysis tells the story. If the firm invests and the competitor does not, it is true that the firm's market share will grow and its cost advantage on the experience curve will widen. However, if it fails to invest and the competitor does not fill the void, no volume will be lost and prices might even improve as product scarcity takes over. Further, the firm's operating rates, i.e. operation as a percent of capacity, would likely improve thus lowering costs. The total effect may well be only a small incremental cash flow and therefore a low present value of further investments in the "star" business.

The preliminary conclusion must be that all "stars" are not always the highest priority investments that the firm has -- if by highest priority we mean those with highest net present value based on incremental cash flows. As it turns out, that preliminary conclusion is only partially confirmed by the model results. This will be fully discussed in the final chapter, "A Wrap Up".

Some might argue that the preliminary conclusion put forth above, while valid for BCG's Share-Growth Matrix that does not consider competition, would fail with a matrix that does. The McKinsey matrix, perhaps the most general of all, specifically lists "competitive structure" as a partial determinant of "industry attractiveness. The closest match McKinsey makes to BCG's "star" is that matrix sector including businesses with a high level of market attractiveness combined with a high degree of business strength. The strategy "rule" given for that sector is to---invest! Without facing the problem of how we rank various determinants, such as high market growth combined with either favorable or unfavorable competitive structure, to calculate market attractiveness, I contend that all portfolio matrix analyses measure the attractiveness to the firm of a business, assuming the competitive equilibrium is not upset. Capital investments, by their very nature, upset the competitive equilibrium. As Henderson (1979:22) says:

> "A business should be regarded as a system in equilibrium. An effective corporate strategy is a predetermined sequence for the allocation of resources in such a fashion that the equilibrium will be shifted to a more favorable relationship."

Therefore, the capital investment decision aspect of strategic planning must explicitly consider competitive reaction quantitatively to accurately measure the attractiveness of further investment in any business. Again Henderson (1979:7, 11) points out:

> "Competitors determine your market share. Competitors determine your price. Competitors determine your return on investment. They do this by their investments...Aggressive competition produces revolution instead of evolution in competitive relationships."

In summary, all portfolio matrix schemes are little help in selecting which businesses the firm should invest in. They are flawed in that they measure the attractiveness of a particular business to the firm and not necessarily the value of additional investments.

CHAPTER 3

THE CONCEPTUAL FRAMEWORK

In Chapter 2, "The Review of Related Research", I attempted to show how capital budgeting theory, traditional strategic planning and portfolio matrix analysis each looks at the problem of deciding which businesses the firm should support with its scarce resources to satisfy or maximize (depending on how you look at it) the goals of the firm. The stated objective of this thesis -- to provide a model that will measure the financial attractiveness to the firm of investing in current or potential SBU's -- is less grand in that it does not actually choose among the SBU's so quantified.

This chapter's goals are to describe the basic framework of that model and to explore in more detail the tools required. The actual integration of those tools into the working model is reserved for the subsequent chapter.

STATEMENT OF THE MODEL AND TOOLS REQUIRED

Any model that attempts to quantify accurately the financial attractiveness to the firm of investing in a current or potential SBU must go far beyond the simplistic, traditional capital budgeting approach of forecasting sales volumes, prices, costs, investment requirements and cost of capital over the economic life of the assets employed. Although, the final result of such a model must be expressed in exactly those terms if the financial attractiveness is to be measured by its net present value.

This model attempts to integrate, as fully as possible, all strategic implications of such investment. It differs from the traditional capital budgeting approach in the following ways. It is truly market-oriented in that it considers important the differences in how competitor's view the size, growth and ultimate end of the market for the product (i.e. the entire product life cycle). It is oriented towards the strengths and weaknesses of each competitor because it explicitly considers their abilities to reduce cost over time (i.e. the slope of the experience curve) and the ultimate limits of each competitor's willingness to commit financial and other scarce resources to the business. Also, it is capable of including synergy effects (i.e. by initial positions on the experience curve).

Further, this model improves capital budgeting theory for those investments with strategic implications in the following ways. It improves the ability of the firm to predict and control competitive response by assuming that "if selected" the business will be managed for dominance (i.e. using limit pricing). It improves the accuracy of long-term cost, price, volume and investment requirements by giving simple rules for the calculation of each (based on the product life cycle, the experience curve and limit pricing). It better measures the incremental cash flows associated with the investment by explicitly recognizing that the net present value of not investing in a current SBU is not zero, but is in effect negative. Finally, it allows for a consistent method to specify what is special about the specific business opportunities, not just what the general economics are for investment in that business.

The obvious place to start in the development of such a model is to describe in more detail the tools to be used; namely, the product life cycle, the experience curve and limit pricing. That is the goal of the rest of this chapter.

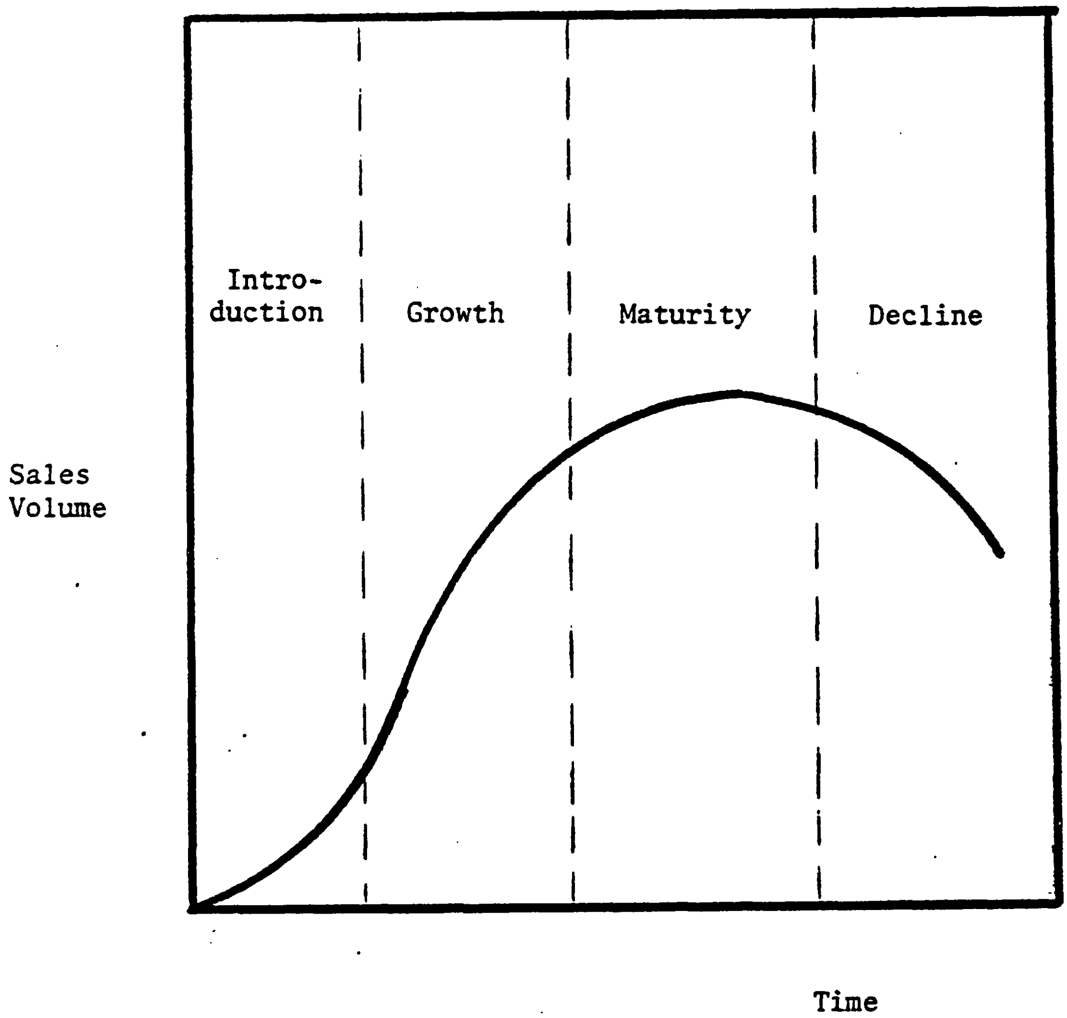
THE PRODUCT LIFE CYCLE

Intuitively, the attractiveness of a particular business to the firm must be strongly related to the market for the product or service offered. A business with sales volume forecast to grow substantially and continue for a long time is more attractive that one in which volume is declining and the end of the product is in clear sight. The reason is directly related to net present value. Everything else equal, an investment will have higher net present value if it has many years of positive cash flow rather than few. A firm must start its search for attractive investment opportunities by understanding the market and forecasting its remaining level of sales over time.

The concept of the product life cycle has been developed in marketing to help forecast sales into the distant future. Marketing texts, see for example McCarthy (1975:231), show four stages in the life cycle of a typical product: introduction, growth, maturity and decline, as shown in Figure 3-1 on the next page.

The typical cycle is explained by the fact that any viable new product must somehow be an improvement over an older product or fulfill an unsatisfied need. Over time sales will grow through this replacement process, ultimately being limited as Buzzell, Nourse, Matthews and Levitt (1972:373) say by the:

FIGURE 3-1. THE PRODUCT LIFE CYCLE



"natural 'ceiling' or saturation level for any product...subsequent changes in sales will be governed largely by changes in the size of the relevant total market."

Ultimately, invention or further improvement will make the product obsolete and sales will decline.

A valid question is, "How realistic is the intuitively satisfying product life cycle?" As always, there is controversy. Research results run the gamut. Levitt (1965) found that sales patterns can frequently be described in terms of the four stages previously discussed. Cox (1967), studying 258 ethical drug products, found six different sales patterns were needed to describe the sample; however, about two-thirds would fit the shape of Figure 3-1 if a second cycle repeating the first was included about the point of the initial sales decline. Polli and Cook (1969:400), studying 140 categories of nondurable consumer products commented on their results as follows:

> "While the overall performance of the model leaves some question as to its general applicability, it is clearly a good model of sales behavior in certain market situations -- especially so in the case of different product forms competing for the same market segment within a general class of products."

On the other hand Dhalla and Yuspeh (1976) maintain that a life cycle is useless as a prediction of sales because products tend to have unique sales growth patterns. As Cravens, Hills and Woodruff (1976:335) say regarding the product life cycle:

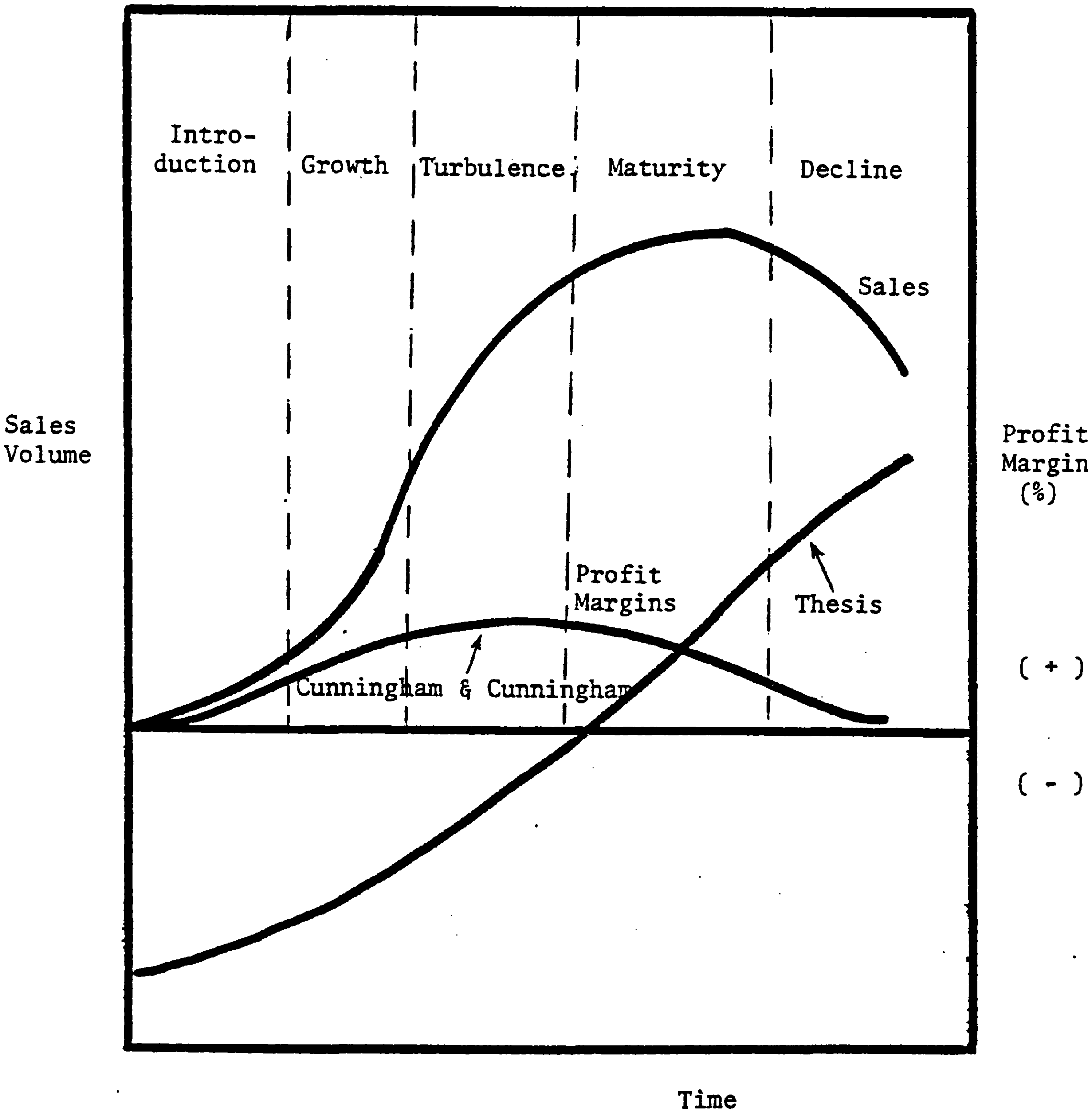
"Certainly, it is not a theory...Yet, there is empirical support to the effect that sales follow definite patterns over the life of a product."

Another usual inclusion in marketing texts is the supposed pattern of profits over the product life cycle. On this point there seems to be substantial disagreement both between text authors and more importantly this thesis. For example, Craven, et.al. (1976:334) show profits at zero at the point of product introduction. Profits peak at the end of the growth phase and decline throughout the remainder of the product's life. More realistically, I think, is McCarthy's (1975:231) approach, showing profits negative during product introduction.

Although it is too early in the development of the model proposed in this thesis to explain fully the reasons, I contend that profit margins (not profits) would be as shown in Figure 3-2, on the next page. The full support for the continually rising profit margins will be explained in a later section entitled, "Price Implications of the Model".

In contrast, I have reproduced Cunningham and Cunningham's (1981:233) five-stage product life cycle and associated profit margin pattern. The essence of the difference in profit margin pattern is that this thesis contends that a new product can achieve its fullest

FIGURE 3-2 PROFIT MARGINS OVER THE PRODUCT LIFE CYCLE



potential, as measured by net present value, if it is managed for market dominance. that is, prices would be very low relative to cost in the life cycle's early stages to discourage competition, encourage market growth and establish an unchallengeable cost position. As the product matures and eventually declines, prices could be raised without risking competitive investment.

The existence of a "standard" product life cycle is not crucial to the development of this thesis. What is needed however, is that the firm be able to forecast what it considers a believable sales pattern over the long-term. And, for the firm to develop what it thinks competitors' views of long-term sales are as well. The concept of the product life cycle is but a tool in this process.

There are, however, two refinements that must be made to the product life cycle to make it fully useful theoretically: (1) Sales patterns should be developed through decline to the ultimate death of the product, and (2) the influence of different pricing strategies on the shape, size and length of the product life cycle must be considered.

All marketing texts reviewed* fail to show the decline phase of the product life cycle continuing

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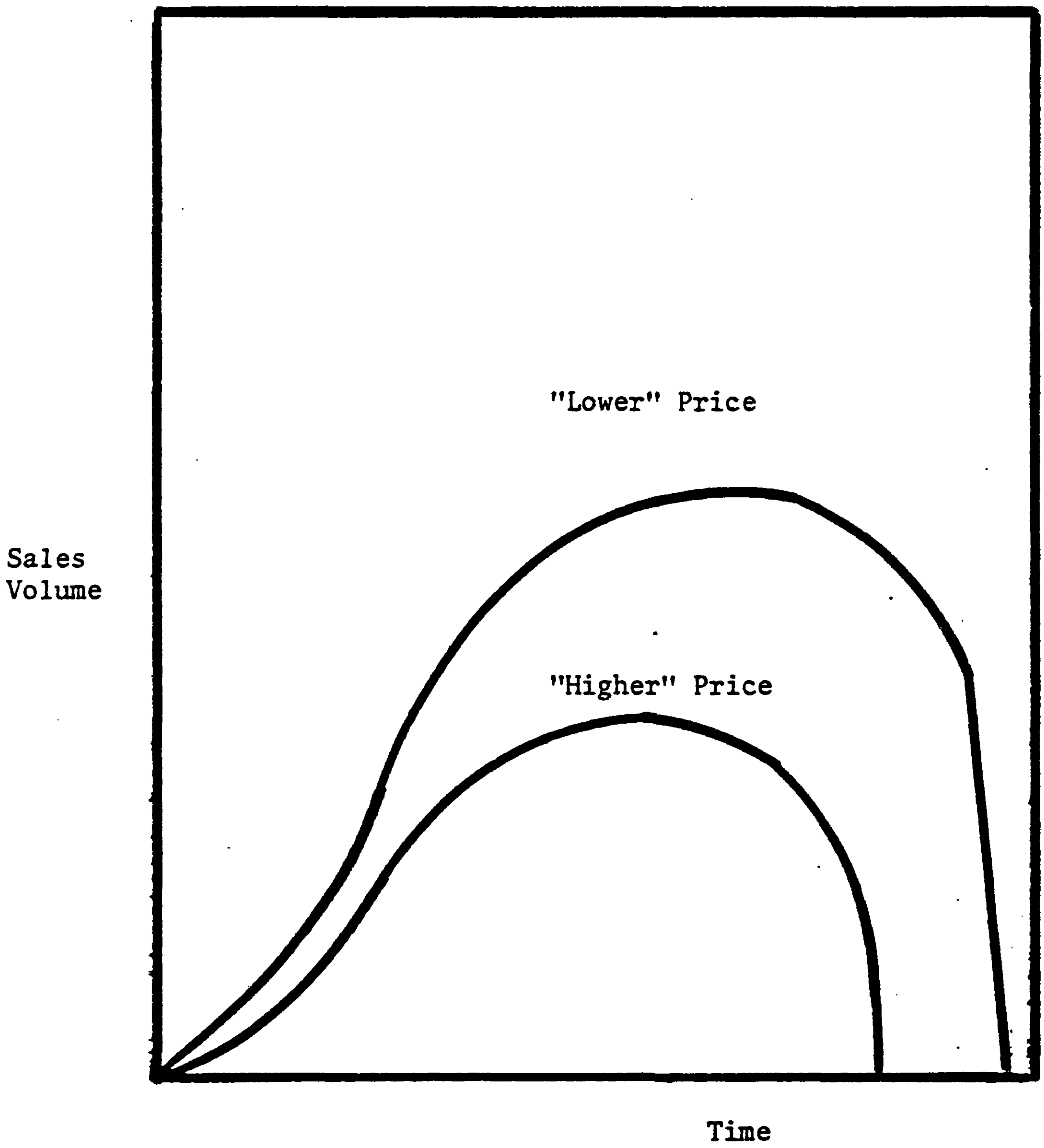
*McCarthy (1975), Buzzell, et al. (1972), Cravens, et al. (1976) and Cunningham and Cunningham (1981).

through time until sales are zero. This failure implies that they consider this final phase unimportant to the firm. This is confirmed when we consider they generally show profits asymptotically approaching zero as the sales decline. However, the final declining stage of the product life cycle is important if profit margins are continually rising over time as proposed in Figure 3-2. Therefore, difficult as it may be, the firm needs to describe fully the life cycle of the product in which it considers investing.

If the firm manages the product for dominance, rather than simply reacting to the market and competition, it must consider the implications of its price strategy on both the size and shape the product life cycle. The relationship is as shown in Figure 3-3, on the next page.

Notice, two curves are shown, one with a lower price strategy than the other. The effects of lower prices are: (1) a steeper growth phase, (2) a higher ultimate level of sales, and (3) a longer life cycle. The reasons are purely market-oriented. A lower price encourages more rapid replacement of the older product, raises the saturation level by increasing the size of the relevant total market and retards obsolescence by removing some of the financial incentive for invention or improvement. If the firm can manage the product, it must search for that price strategy, when combined with expected competitive response, which yields the highest value to the firm.

FIGURE 3-3. THE EFFECT OF PRICE STRATEGY ON THE PRODUCT LIFE CYCLE



LONG-RUN COST ESTIMATION AND THE EXPERIENCE CURVE

From a strategic perspective, the firm with a cost advantage over competition will be in a superior position, all else being equal. It will have higher profits and cash flow and will require less externally provided cash to grow with the market. Therefore, proper strategic planning as well as capital investment theory demands that business unit costs be estimated over the long-run, preferably over the entire product life cycle.

The purpose of this section is threefold. First, to look at microeconomic theory, with the goal of determining the proper shape of the long-run average cost curve and its implications for strategy. Second, to review the learning curve and its extension by the Boston Consulting Group into the experience curve. Third, since the experience curve is heavily used in the remainder of this thesis, criticisms of the experience curve need to be addressed and their validity weighted.

Economic theory

Traditional microeconomics assumes that the long-run average cost curve is U-shaped. As Hawkins (1973:44) explains:

> "The initial fall (in cost) is assumed to reflect economies of scale which continue until output is raised to an optimum plant size; thereafter diseconomies of scale are assumed to set in."

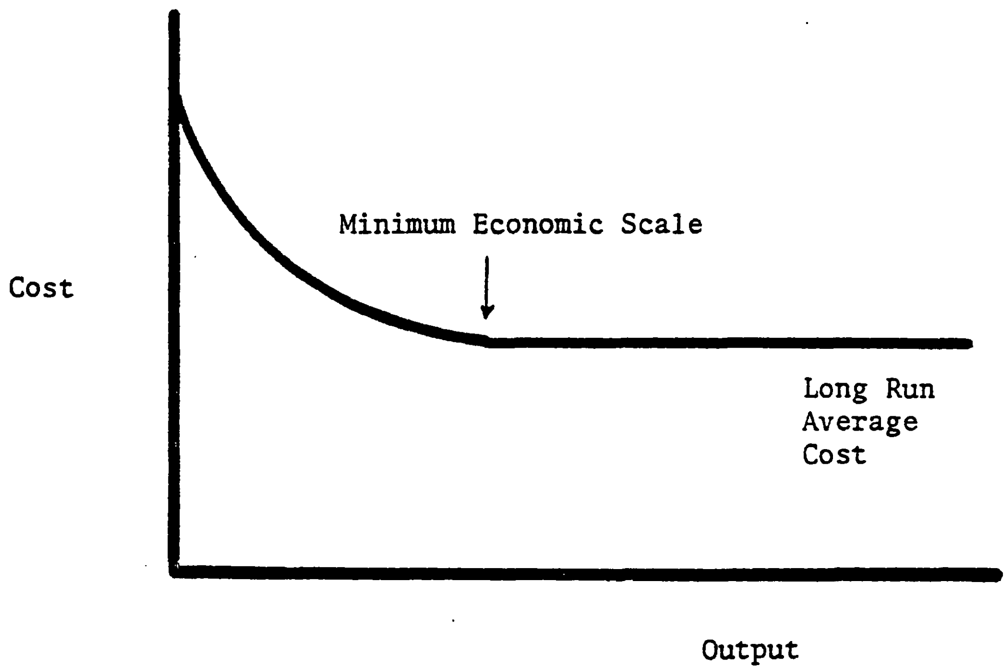
However, there is substantial empirical evidence to suggest that assumed diseconomies in ~~management,~~ administration and other functions do not occur and that costs do not generally rise as firms expand production. Studies by Pratten (1971) and Silberton (1972) and others suggest that long-run average cost curves are L-shaped -- either flat or falling as shown in Figure 3-4 on the next page.

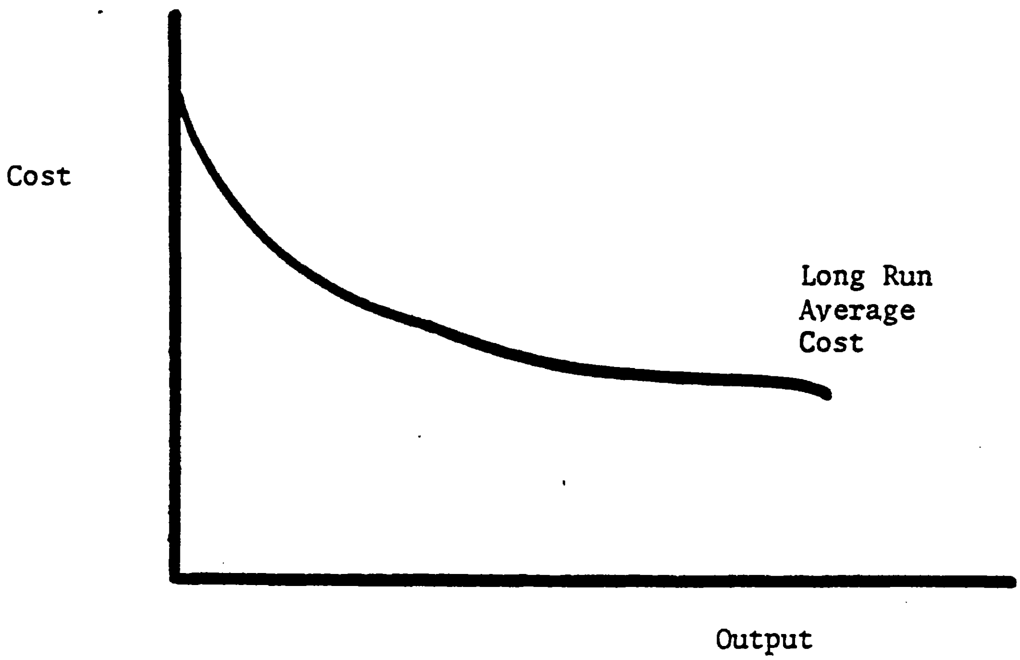
Proponents of the U-shaped long-run average cost curve make the theoretical argument that there must eventually come a point, as output increases, when diseconomies of scale will make themselves felt. Arguments about what will happen to costs at some hypothetically extreme output level are impossible to refute with evidence. However, even the great pioneers of microeconomics have recognized effects in the real world that would imply L-shaped curves. As reported by Hawkins (1973:45), John Stuart Mill noted that:

> "There is a tendency to substitute more and more, in one branch of industry after another, large establishments for small ones."

Also, Alfred Marshall saw that the production of certain commodities might conform "to the law of increasing returns in such a way as to give great advantage to large producers." Based on available statistical evidence, it

FIGURE 3-4. LONG-RUN AVERAGE COST CURVES: FLAT VS. FALLING





does appear that we should accept that for many products L-shaped average cost curves best fit the empirical evidence.

As Hawkins (1973:47) summarizes, that with an L-shaped long-run average cost curve,

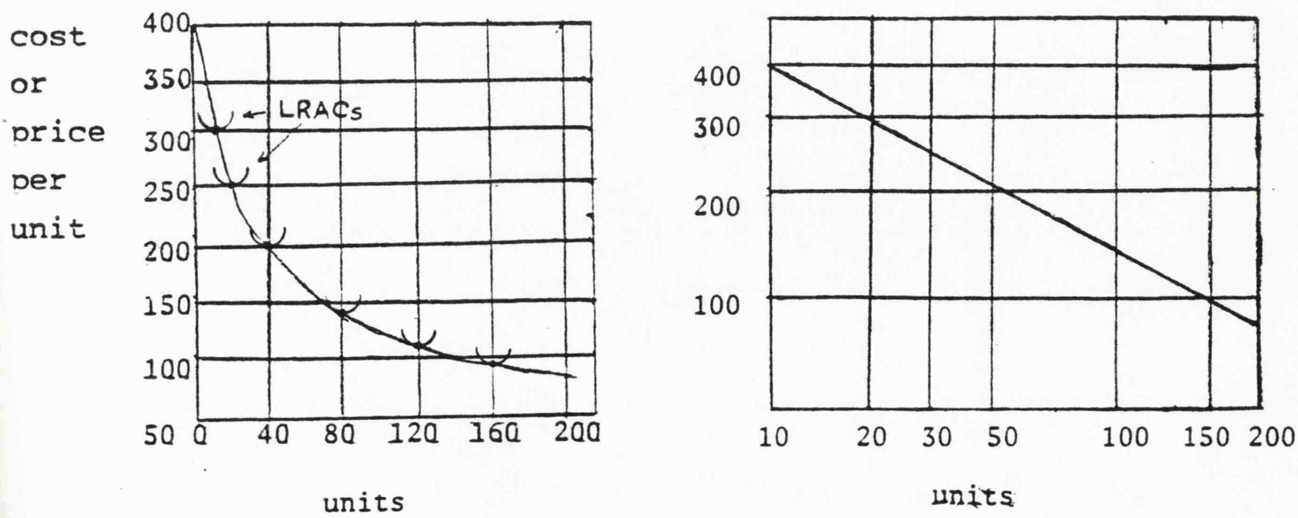
> "Perfect competition is seen to be impossible...It is always profitable to expand output and eventually the firm must reach the situation in which it can affect the market price...The significant point is that in those industries where economics of scale extend out to very large levels of output (i.e. a falling L-shaped cost curve) the number of firms in the industry will become very small, ultimately perhaps being reduced to one."

monopoly

To describe the relationship of the long run average cost curve from economics to the learning curve and the experience curve requires that the LRAC be considered dynamic rather than static. Generally, the LRAC is a static concept in that it does not allow for cost changes other than through economies of scale. For example, if sales were 100 units per year and the minimum point of the short run average cost curve intersected the LRAC at that point, where the cost was $10, then the static nature of the LRAC would suggest that the cost will be $10 in the future as long as sales remain constant.

However, considering the dynamics of technological change we should expect lower costs over time. Bixby, Rucker and Tisdale (1964) found exactly that shifting downward in the LRAC of ammonia production caused by process and raw materials changes. Since technological change is but one form of "learning" or "experience", both curves use empirical evidence to predict the rate at which the LRAC shifts downward. If the rate at which the dynamic LRAC shifts is a function of cumulative production volume, then a dynamic LRAC and the experience curve are exactly the same thing, and it requires only a small change to transform the downward shifting L-shaped LRAC into the experience curve. If the axes of the dynamic LRAC are changed from linear to logarithmic scale, the L-shape becomes a straight line as shown in Figure 3-5.

FIGURE 3-5 L-SHAPED LONG RUN AVERAGE COST CURVES



Learning curves

To describe the decline in the hours of labor required to produce a product, it has become customary to speak of a "learning curve". The learning curve shows that for standardized products, manufacturing cost fall as volume rises. Some of the earliest reported learning curve effects were isolated in the aircraft industry during World War II -- see Carr (1946) and Crawford and Strauss (1947). Hirschman (1964) recognized the strategic implications of relative cost difference among competitors, and showed that a straight line relationship could be drawn between constant dollar cost and cumulative units produced when plotted on a double logarithmic scale. Further, he found that for each doubling of the accumulated production experience the unit cost would fall to about eighty percent of the previous level, depending on the mixture of man and machine work involved.

The experience curve

The Boston Consulting Group (BCG) (1968) picked up on Hirschman's ideas and combined them with widely available data on prices (not costs) and industry production experience. They found that prices decline about twenty percent for each doubling of cumulative experience, just as Hirschman found for learning curve related costs. BCG (1968:10) supported their position, looked at a number of products and industries (e.g. electric power, Japanese beer and paraxylene), and observed that:

> "This decline goes on in time without limit (in constant dollars) regardless of the rate of growth of experience. The rate of decline is surprisingly consistent, even from industry to industry."

From this data BCG infers that if prices show a systematic decline with experience, then costs (all costs not just manufacturing costs as theorized by the learning curve) must also decline similarly with experience. In their words,

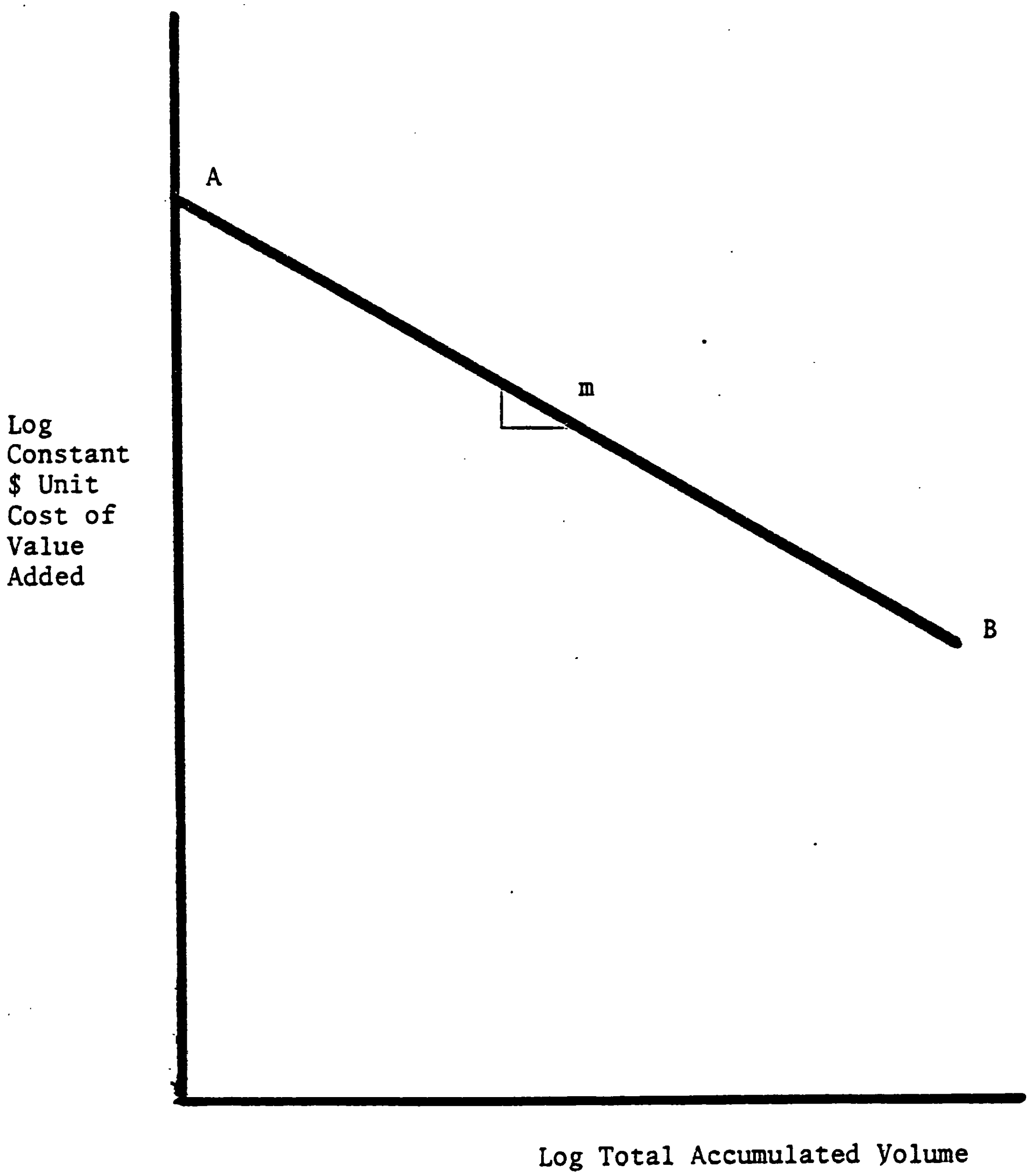
> "(constant dollar) costs appear to go down on value added at about 20-30% everytime product experience doubles."

When such a relationship is graphed, it appears as in Figure 3-6, on the next page.

Point A denotes the cost of value added for the first unit produced and Point B similarly denotes the cost of value added of the last unit produced during the product life cycle, both expressed in constant dollar terms. The slope of the line reflects a 20-30% decline in the cost of the value added for each doubling in total accumulated volume.

To simplify discussing experience curves, the following conventions will be observed: (1) "costs" will mean the constant dollar cost of the value added, (2) "prices" will mean constant dollar prices, (3)

FIGURE 3-6. THE EXPERIENCE CURVE



"experience" or "cumulative volume" will mean total accumulated volume, and (4) graphs portraying the experience curve effect will always be on a double logarithmic basis.

Do costs fall automatically with increased experience? No, unless the firm's management seeks ways to reduce costs as physical volume grows and keeps up cost reduction pressure over the product's life. Such pressure on costs is reasonable, given the firm's need to remain competitive and the firm's desire to be as profitable as possible. In the words of the Boston Consulting Group (1970:1)

> "...the relationship (of the experience curve) is of normal potential rather than one of certainty. However, competition characteristically produces survivors who achieve the full potential."

If the experience curve is a valid tool, the implications for strategic planning and capital budgeting are many. For example, if we know current costs, and our cumulative volume and we can predict industry sales volume and our market share, we can also predict costs far into the future. Given the assumptions in Figure 3-7 for industry sales volume and our market share with an initial cost of $10.00 per unit and an experience curve slope indicating a 30% decline in cost for each doubling of cumulative volume, annual costs can be calculated.

FIGURE 3-7. UNIT COST AS A FUNCTION OF EXPERIENCE

YEAR (t)	INDUSTRY SALES VOLUME	MARKET SHARE (%)	SALES VOLUME	CUMULATIVE SALES VOLUME (N_t)	UNIT COST (C_t)
0	100	50	50	50	10.00
1	200	55	110	160	5.50
2	300	60	180	340	3.73
3	400	65	260	600	2.78
4	500	70	350	950	2.22
5	640	75	480	1430	1.78
6	800	75	600	2030	1.49
7	700	80	560	2590	1.31
8	400	80	320	2910	1.24
9	200	80	160	3070	1.20
10	100	80	80	3150	1.19

In the above table, unit cost each year (C_t) is calculated from beginning cumulative sales volume of 50 units (N_o), beginning unit cost of \$10.00 (C_o), and cumulative sales volume each year (N_t) according to the relationship:

$$\log C_t = \log C_o - E \log (N_t/N_o)$$

or simplifying,

$$C_t = C_o(N_t/N_o)^E$$

where E = -0.51457, which corresponds to an experience curve slope with a 30% decline for each doubling of cumulative volume. The power coefficient E equals -0.51457 simply because the logarithm of a 30% decline for a doubling in volume or log 0.7 divided by log 2 = -0.51457.

Further, if we can determine our competitors' cumulative volume now and predict their market share, we can also forecast their costs if we know the slope of their experience curve. For example, let us assume that we have but one competitor, whose experience curve slope and initial unit cost is the same as ours. Using the same assumptions of Figure 3-7 regarding industry sales volume and recognizing that the competitor's market share and ours would add to 100%, his unit costs are as shown in Figure 3-8, on the next page.

Notice the implications of the experience curve as shown in Figure 3-9 on the second following page. Both firms' costs decline sharply early in the product life cycle while industry sales volume is growing quickly. As industry sales volume growth slows and turns negative, both firms' costs continue to decline, but at a progressively slower rate. Most importantly, the experience curve implies that the only reason that our costs are lower than our competitors is that our cumulative volume exceeds his due to higher market share. Since we would both face the same market price therefore, the firm with higher market share over the product life

FIGURE 3-8.

COMPETITOR'S UNIT COST AS A FUNCTION OF EXPERIENCE

YEAR (t)	INDUSTRY SALES VOLUME	HIS MARKET SHARE	HIS SALES VOLUME	HIS CUMULATIVE SALES VOLUME (N_t)	HIS UNIT COST (C_t)
0	100	50	50	50	10.00
1	200	45	90	140	5.89
2	300	40	120	260	4.28
3	400	35	140	400	3.43
4	500	30	150	550	2.91
5	640	25	160	710	2.55
6	800	20	160	870	2.30
7	700	20	140	1010	2.13
8	400	20	80	1090	2.05
9	200	20	40	1130	2.01
10	100	20	20	1150	1.99

FIGURE 3-9. COMPARATIVE UNIT COSTS

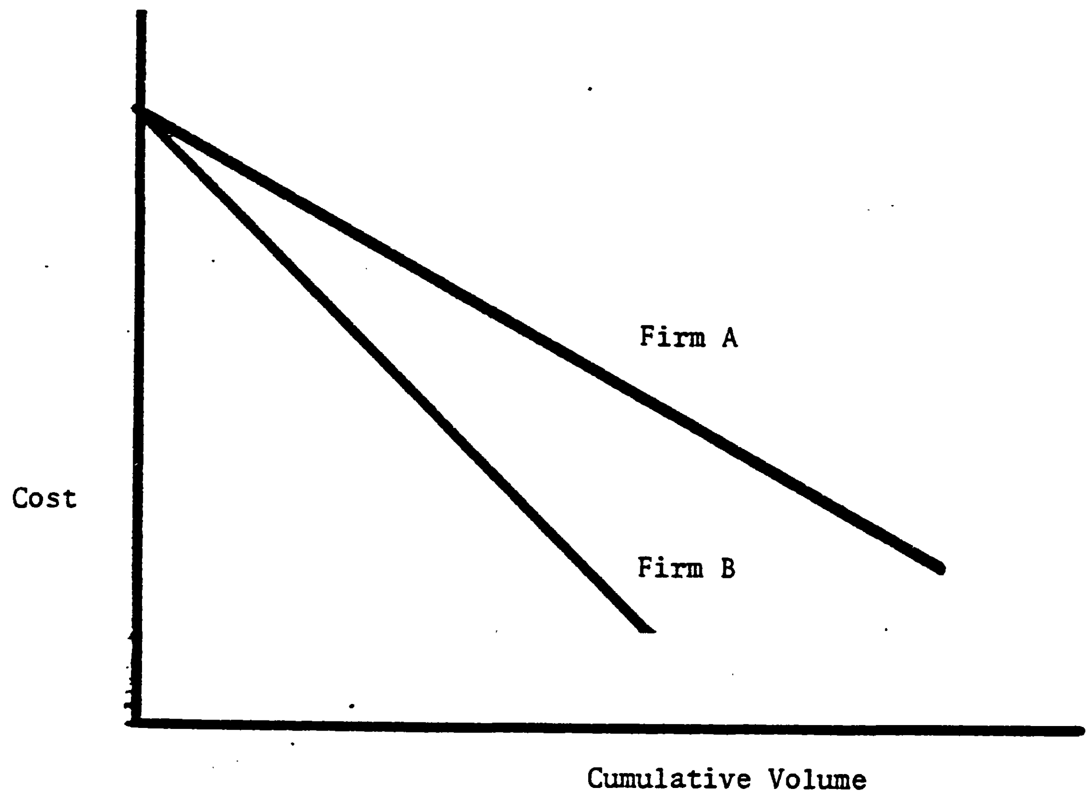
YEAR	INDUSTRY SALES	CHANGE IN INDUSTRY SALES(%)	OUR COSTS	HIS COSTS	OUR COST ADVANTAGE	OUR COST ADVANTAGE AS % OF HIS COST
0	100	--	10.00	10.00	--	0
1	200	+100	5.50	5.89	.39	7
2	300	+ 50	3.73	4.28	.55	13
3	400	+ 33	2.78	3.43	.65	19
4	500	+ 25	2.22	2.91	.69	24
5	640	+ 28	1.78	2.55	.77	30
6	800	+ 25	1.49	2.30	.81	35
7	700	- 13	1.31	2.13	.82	38
8	400	- 43	1.24	2.05	.81	40
9	200	- 50	1.20	2.01	.81	40
10	100	- 50	1.19	1.99	.80	40

cycle could expect higher profitability, as the cost advantage grows.

The quantitative analysis of the experience curve has so far assumed that each competitor's experience curve has the same slope; that is, each competitor is equally able to translate experience into lower cost. Certainly, at first glance, the assumption does not appear to be valid. Some firms prosper while others go bankrupt. However, consider the long-run implications of differences in the slope of the experience curve from Figure 3-10.

FIGURE 3-10.

COMPETITORS WITH DIFFERENT EXPERIENCE CURVE SLOPES



Firm B has an experience curve with a greater slope than that of Firm A. Therefore, for any level of experience, B's costs would be lower than A's costs. For a non-differentiable product in a perfectly competitive market, the price would tend to follow the path of the lowest cost producer's costs and eventually A would find itself unprofitable. Given the different slopes of the experience curves, the only way A's costs could be competitive with B's costs is if A could increase its cumulative volume faster that B. In other words, A would have to increase continuously its market share to make up for its slower rate of cost reduction. Obviously such a plan would be difficult to sustain, particularly as A's market share becomes larger.

What are A's realistic options if initially confronted with the conditions of Figure 3-6, i.e. a lower slope on their experience curve? Certainly the most obvious is to copy the conditions that allow B to be more successful. That would include attempting to duplicate B's manufacturing process, scale size and techniques, plant locations and labor conditions, product design and engineering, distribution systems, research and management organizations and all other factors that combine into total unit cost of product sold. Methods to achieve such a goal ethically, might include hiring away key employees familiar with B's operation and methods, studying all public information regarding B's operations, such as patent applications and performing "reverse engineering" on its product. Most importantly, A would need an organization, at least as competent as B's, in finding future ways to reduce cost. Such a plan is nothing more than a commitment by management to get and stay competitive. As the Boston Consulting Group (1968:1) says,

> "Any failure...to relate any one of (the) cost elements (required to deliver the product to the ultimate consumer) properly to the others will have a degrading effect on the cost performance in serving the end user. This may be why the experience curve works as it weeds out everyone who has not used the optimum combination of cost elements compared to his competitors combinations."

What is the effect when competitors start in business at different times? Clearly, a late entrant's costs are above those of a competitor who has already accumulated experience. Total unit costs are determined by organization coordination and learning as well as scale effects, capacity utilization and many other factors besides simple know-how and technology. However, the last entrant's costs are not necessarily as high as the first producer's costs initially. The late entrant's starting costs will be a function of his ability to combine the knowledge gained so far by his competitors with the current technology of production. For example, let us consider the conditions assumed in Figure 3-11, namely, the first producer has a starting cost of $10 per unit in year 0 and the late entrant's starting cost is $6.72 per unit in year 2 is 50% more than the first producer's cost that year. Both competitors' sales grow at a rate of 50% per year.

FIGURE 3-11. LATE ENTRY'S EFFECT ON THE UNIT COST UNDER THE EXPERIENCE CURVE

	FIRST PRODUCER		LATE ENTRANT		UNIT COST	
YEAR	SALES	CUMULATIVE SALES	SALES	CUMULATIVE SALES	FIRST PRODUCER	LATE ENTRANT
0	100	100	0	0	10.00	--
1	150	250	0	0	6.24	--
2	225	475	100	100	4.48	6.72
3	338	813	150	250	3.40	4.19
4	506	1319	225	475	2.65	3.01
5	759	2078	338	813	2.10	2.28
6	1139	3217	506	1319	1.68	1.78
7	1708	4925	759	2078	1.35	1.41
8	2563	7488	1139	3217	1.09	1.12
9	3844	11332	1708	4925	.88	.90
10	5767	17099	2563	7488	.71	.73

The calculation of unit costs indicates that the late entrant's costs will eventually catch the first producer's costs. The ratio of approach is dependent on how fast sales grow and the late entrant's starting cost, assuming market shares are constant. The faster the growth rate in sales, the quicker the approach. The lower the late entrant's starting cost, the quicker the cost's approach.

The strategic implications of the experience curve are again clear. Cost reduction knowledge gained any way other than through individual experience is very valuable to the late entrant and very costly for the first producer if he wishes to maintain a significant cost advantage. Hence any firm developing a new product could wisely invest significant sums in protecting its proprietary secrets and potential competitors could wisely invest significant sums in discovering those proprietary secrets, particularly when the product growth rate is high.

Criticisms of the experience curve

Criticism of the experience curve is basically of four types:

1. Simplistic criticisms caused by misunderstandings of the concept as presented by BCG.

2. Organization arguments that basically

imply that, following the implications of the experience curve, poisons the firm's ability to accomplish rapid rates of product innovation and improvement in product performance.

3. Arguments that contend that even if the experience curve phenomenon is real, it is no longer useful in the "era of slow growth."

4. Very recent criticism by some economists arguing that the experience curve does not exist.

We will explore each of these criticisms, briefly in the case of the first three; the fourth in some detail.

The first criticism -- simplistic misunderstanding -- is perhaps best put forward in the following quote by Kiechel (1981:139)

> "the sweeping downward arc of the experience curve hung like a guiding constellation over the business landscape of the 1970's...It was the curve that tied together (the notion that market share was important or that being low-cost producer conferred special benefits) with ineluctable logic. The news for the

> 1980's...is that the curve is being consigned to a much reduced place in the firmament of strategic concepts. With it is going a good bit of the importance originally attached to market share."

The reasons for the decline, as cited by Kiechel, are related to the firm's difficulty in executing a strategy of increasing share.

Some firms attempted to cut prices in the hope of picking up share. The predictable result was a price war they found unpleasant. Clearly, though, if the benefits of high market share are as attractive as BCG portrays, it should not be surprising that a significant investment of resources would be required. Perhaps such firms had too short a time horizon or insufficient commitment to the battle.

Other firms found that getting costs to proceed down the experience curve was no easy matter. It required constant management attention, pursuing new technologies, pruning inefficient and/or superfluous functions and people, and adding new and expensive capacity to grow with both the market and the increasing share. These findings are exactly consistent with BCG's projections. Perhaps such firms did not really understand the implications of the decision to increase share or they misread the size of the financial investment required.

Worst of all, some firms who were successful in dominating their market and were anticipating the rewards, found their customers ready to switch to cheaper substitutes as they developed. Clearly, such firms erred in their forecast of the product life cycle -- they only waited too late to raise prices and reap their reward.

The conclusion has to be that for a firm to be happy with the results of employing the strategy implied by the experience curve it must have a long-term horizon, it must be accurate in its prediction of the product life cycle, and it must have both the financial resource and the internal commitment to use them to win the war.

Organizational theorists have criticized a cost minimization strategy (i.e. an expanding market share strategy) on the grounds that an organization geared toward reducing cost has a reduced ability to make innovative changes in their products and a reduced ability to respond to those introduced by competitors. Peters and Waterman (1982:157) found that "excellent" companies seem to focus especially on the revenue generating side through commitment to quality, reliability or service; not necessarily desiring to be low cost producer. In further support of this criticism Abernathy and Wayne (1974) cite the early days of the Ford Motor Company.

In 1909, Ford consolidated its production line to the Model T, an open-bodied touring car. At that time, the list price of a Model T was about $3100, expressed in 1958 dollars. Thereafter Ford followed almost singlemindedly a cost minimization strategy for the Model T, even to the point of opening coal mines and rubber plantations for backward integration. By 1925, the list price of the Model T was under $900, again expressed in 1958 dollars. However, unit sales had peaked in 1923 as consumer demand shifted to a heavier, more comfortable, closed-body car. Thereafter, Ford never recovered its dominance. Ford, unbeatable at making one product efficiently, was vulnerable to GM's strategy of quality and superior performance.

Abernathy and Wayne (1970) contend that Ford's problems originated from the fact "product innovation is the enemy of cost efficiency, and vice versa". They see two ways to limit the damage:

> "One is to maintain efforts to continue development of existing high-volume product lines. This requires setting the industry pace in periodically inaugurating major product changes while stressing cost reduction via the learning curve between model changes."

> "The second course of action is to take a decentralized approach in which separate organizations or plants in the corporate framework adopt different strategies within the same line of business."

IBM is cited as an example of the former strategy and DuPont, an example of the latter.

This criticism is not one that directly challenges the existence or usefulness of the experience curve. In fact, if anything it supports it. However, if the contention is true that organizations are incapable of coping with cost reduction and innovation simultaneously, then further work is needed:

* Either organizational research must be undertaken to eliminate the conflict between cost reduction and innovation, or if unsuccessful.

* Corporate strategies must attempt to quantify the innovation penalty into the rewards of lower cost positions, perhaps through the tool of the product life cycle.

This thesis ignores this criticism of the experience curve, essentially because the contention is controversial and even if proven, the effect could be incorporated into the model proposed in this thesis.

The third type of criticism, while not challenging the existence of the experience curve, argues that its importance is drastically reduced in the current "era of slow growth". This criticism, as reported by Kiechel (1981:146), is attributed to Alan Zakon, then head of the

Boston Consulting Group. This criticism can be challenged on at least four fronts. First, it can be argued that the slow growth of the last decade experienced by the industrialized economics is cyclical rather than structural, along the lines proposed long ago by Kondratieff (1935), and interest in the experience curve will again revive with the economy. Second, it can be argued that even if business is now destined to grow at a slower pace, capital investment decisions will by their very nature have to be made in those business segments that do show significant growth. Therefore, the experience curve is still useful in capital budgeting even if it has become less important in guiding operating decisions.* Third, from the standpoint of model building, it can be argued that if the experience curve is generally thought to exist, it should be included in the model's assumptions because as Cohen and Cyert (1975:18-19) say

> "...assumptions characterize the type of world to which the model is intended to apply. It is

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*Hammermesh and Silk (1979) give ground rules for managing low growth businesses which include concentrating on growth segments, being innovative and quality oriented and being attentive to all cost reduction opportunities.

> important to realize that the assumptions need not be exact representations of reality, but they may instead be reasonable abstractions of reality."

Fourth, it can be argued that including the experience curve effect in any model measuring the financial attractiveness of investments in SBU's is no less important in times of slow growth than is including the concept of discounting cash flows in times of low interest rates.

The final, and most important, criticism of experience curves challenges their very existence. Hart's (1983:96) position can be summarized as follows:

> "Published evidence for their (i.e. experience curve) existence is not always convincing. Even if they do exist, they are merely mongrel relationships reflecting many economic forces including technical progress and economies of scale in addition to 'learning' or 'experience'."

Hart's point is primarily based on a comparison of the costs of generating electricity in the U.S. versus the U.K. for the period 1943-68. He compared a time series estimate of costs based on the experience curve with cross-section estimates of the effects of size of generating plant together with estimates of technical progress obtained by stratifying the cross-sections by age of plant. Hart (1983:101) found that at least 92% of the decline in cost could be explained by scale and technical progress leaving as he says, "little left for `experience' or `learning' to contribute."

Hall and Howell (1983) attack the economic underpinnings of the experience curve on a number of fronts. For example, using BCG's data for Japanese beer and integrated circuits, they found that when relating price to cumulative output through the experience curve they got an R^2 of 0.97 and 0.93 respectively, but when they related price to current output instead of cumulative output, R^2 was 0.98 and 0.92 respectively. As Hall and Howell say, "Clearly on this evidence there is nothing to choose between the effect of accumulated and current output." They also offer reasons why other investigators found that statistical evidence supports a relationship between cumulative volume and cost. However, the explanations they suggest make the correlation spurious. For example, they say that using cumulative volumes as the independent variable damps the data due to high autocorrelation of successive points. Also they claim the accounting life of assets is significantly understated when compared to economic life, guaranteeing a cost decline over time. Hall and Howell (1983:26) summarize their criticism as follows:

> "...establishing a statistical relationship... between costs and accumulated output will not in itself prove useful. If the reason lies in economies of scale, potential entrants and established firms alike would be faced with decisions concerning the outcome of complex game-theoretic situations. Technological progress, on the other hand, may in certain circumstances ease entry...Learning-by-doing will serve as a barrier to the extent that experience is non-transferable through the market for human capital."

If the experience curve is truly a "mongrel" relationship and costs can decline markedly without accumulating volume, the implications for the model proposed in this thesis are major. Basically, the value of early and continued market share leadership would be drastically reduced, contrary to the portfolio matrices, the PIMS studies, and even traditional microeconomic theory assuming a downward sloping L-shaped long-run average cost curve.

This thesis elects to assume the existence of the experience curve, as described by BCG. The reasons include a preponderance of use and popularity within the business community, and the fact that the criticisms of the existence of the experience curve are very recent and have not as yet been fully debated in academic circles.

Even Hall and Howell (1983:27) recognize the usefulness of the experience curve to business as a self-fulfilling prophesy:

> "Vague notions of the benefits from experience have strong intuitive appeal, whilst graphs depicting accumulated data provide an apparent validity. Thus motivated to reduce costs the management of a firm riddled with inefficiency will usually achieve success."

Adjustments to the model, as proposed in this thesis, that would be required if the experience curve is really no more than economies of scale must logically await the description of another tool; i.e. limit pricing and a full description of the model. Such adjustments will be further discussed in Chapter 6, "A Wrap Up".

LIMIT PRICING

Conventional microeconomics clearly shows that monopolists and oligopolistics can make more than economic profit in any business if they can artificially restrict the quantity of product produced and thereby charge a price greater than their marginal cost. See for example Samuelson (1980). It follows logically that the financial attractiveness of investing in any particular business unit must be a function of whether the firm will have absolute monopoly power, the reduced power of oligopoly or fully face the market in pure competition. Strategic planners, particularly the Boston Consulting Group, implicitly recognize the importance of market share, as a surrogate for monopoly power, in determining business attractiveness. Limit pricing is the tool of microeconomics that allows the firm to control or limit the expansion plans of its competitors through its pricing strategy. If successful, the firm may have the ability to control its degree of monopoly power over the product's life cycle. The first goal of this section is to qualitatively discuss the mechanism of limit pricing for both small and large scale competitive threats to the firm. The second goal is to describe the effects of the experience curve on limit pricing and to review the complication of multiple competitors to limit pricing theory. A more detailed and quantitative discussion is reserved, for sake of readability, to Appendix 1. Much of the material reviewed is from Scherer's (1980) work on industrial market structure and economic performance.

If a firm has dominance in a particular market, either as a result of new product invention or as result of past good fortune, it may lose that dominance in either of two ways. If the firm's market share is less than 100%, so that other small scale or "fringe" competitors currently exist, those fringe competitors or other similar potential small scale competitors may choose to enter the market or expand their market share, if the economics are attractive. In this case, such competitors would likely view the dominant firm's price as a given, and would proceed to produce to the point where the price equals their marginal cost. They can reasonably assume their influence on price will be negligible because their output is small by definition when compared to the total market. A second threat to the dominant market position of the firm comes from potential competitors entering on a large scale. In this case, it is reasonable to assume that a firm considering a large scale entry has reason to fear that its output can only be absorbed by the market if the price falls below that currently set by the dominant firm. Let's look at how the dominant firm can price so as to discourage both types of threats.

Small scale competitive threats

By definition, small scale or fringe competitors view the dominant firm's price as a given. The problem for the dominant firm is to choose the best price, from its own perspective, considering the likely output of the competitive fringe at whatever price set. Obviously, if the firm sets a price below the fringe's minimum marginal cost, the fringe will supply nil, and the dominant firm will capture the entire demand. Similarly, at a sufficiently high price the entire market demand will be supplied by the fringe leaving nil for the firm.

Assume the firm announces a price between those two extremes, in fact a price that equates its marginal revenue with its marginal cost to yield short run maximized profit. What effect will such a price have on the expansion plans of fringe competitors? The answer must be a function of where the announced price falls with respect to the fringe competitors' average total cost. If the price is above, the fringe will have an economic incentive to expand. If below, no expansion will occur. The limit price, that is the price that limits small scale competitors'expansion, is simply the price that equals the average total cost of the fringe.

Generally, this limit price can be expected to be below the firm's short run profit maximizing price. The decision the dominant firm faces is either higher short run profits, declining over time as market share is eroded by fringe expansion, or lower limit pricing profits remaining constant over time as market share is maintained. Both assuming cost functions remain unvarying over time, i.e., no experience curve effect. The proper solution to this dilemma depends upon the discount rate applied to the firm's cash flow alternatives and the rate at which the competitive fringe will expand output at the dominant firm's short run profit maximizing price.

Large scale competitive threats

The second threat to a dominant firm's market share is the threat of large scale entry. A competitor considering entering the market on a large scale must reasonably assume that his incremental output will affect the market price, unless he believes that the monopolistic or oligopolistic group will reduce their output sufficiently to "make room" for the new entrant.

Bain (1956), a pioneer in limit pricing theory, considers that the most likely assumption of the potential large scale entrant will be that established firms will maintain production in the face of new large scale entry. This reaction by established producers, while lowering profits for all competitors, may be useful in discouraging other large scale entry and would result in lower unit costs of production, though not higher profits, by operating at designed capacity, instead of substantially less than capacity.

For the sake of simplicity, let us assume that the new large scale entrant can produce the product at the same unit cost as the dominant firm. What other factors may discourage large scale entry? Clearly the new entrant, with competitive costs, must be concerned that his output will drive the market price below a level that makes his investment in the business attractive. If that occurs, the new entrant will also have destroyed the profit potential of the market for the dominant firm -- by analogy, murder and suicide. The factors that influence how low the market price will fall, assuming output maintenance by established producers and equal cost functions, are the degree of elasticity of market demand and the relative amount of incremental production required by the new entrant to operate at competitive cost. As Scherer (1980:244-45) quantifies , if the elasticity of demand is 1.0 and the incremental output required to be cost competitive is assumed to be 10% of previous market demand, then the price will fall about 9%. With the same elasticity on a required incremental output of 5%, the price will fall only about 4.5%. Should the required incremental output be 10% but elasticity becomes 5.0 instead of 1.0, the price will fall only about 2%. As a rule, the smaller the minimum efficient operating scale, i.e. the smaller the incremental output required to reach competitive cost, and the higher the elasticity of demand, i.e. the more willingly the market absorbs an increment of production without a large decline in price, then the less the dominant producer can safely hold the price above the competitive cost, without attracting large scale entry.

Therefore, to prevent large scale entry the dominant firm must set a price at the potential large scale entrant's minimum total cost plus an amount slightly less than the amount the market price will fall if entry does occur. Such a strategy will effectively remove the financial incentive of the potential large scale entrant.

Perhaps the world is not as predictable as just described. Wouldn't the established producers really make some accommodation with the new entrant on volume and prices once new entry had occurred? Surely, such accommodation would result in higher profits for all producers, particularly when it is realized that the new entrant will not be forced to withdraw from the market due to low accounting earnings once his investment expenditures are made and his fixed costs incurred. And, similarly, would the dominant firm really have to set a price at the limit price described? Surely, he would maximize profits in the short run and at the first hint of interest in the market by a potential large scale competitor, drop prices to the limit price level or perhaps below to "show the flag". The real answer probably can not be determined analytically from economics alone. Competitive actions and reactions are also determined by the ability of the players to effectively use the bluff and counter bluff of business brinksmanship.

Is the potential new entrant really discouraged by a price based on the assumption that established producers will maintain output? The new entrant can clearly show that logically, if he enters, the established producers will be better off if they recognize their oligopolistic interdependence with the new entrant and treat him as a member of the "club". A deterrent that cannot be believed cannot deter entry! The potential new entrant must assume that the established producers will act irrationally, i.e. not in their own best interest, to be effectively deterred from entering the market at the calculated limit price. An established producer can go a long way toward making the limit price a believable deterrent to the new entrant if he "rattles the sabres" by cultivating the impression that he will act irrationally or that events will get out of control and price discipline will break down. An occasional new entrant will call that bluff and an established producer must be prepared to act "irrationally" occasionally if such a threat is to be believed by other or future large scale new entrants. In support, Cassady (1963) found that irrational reaction by established sellers to new entry was a common cause of destructive price wars.

Could established producers hold the price at the short-run profit maximizing level and reduce it to the Bain's limit price when a potential new entrant began to show interest in the market? He probably could, but it would be a dangerous and high risk strategy. Bain (1956:95) explained a reason that the established producers would stick with a lower limit price instead of a higher short-run profit maximizing price as follows:

> "The (potential large scale new) entrant is likely to read the current price policies of established firms as some sort of a `statement of future intentions' regarding their policies after his entry has occurred."

In other words, the higher price is very risky, because a mistake of intentions might be made. Such a mistake would be disastrous for both established producers and the new entrant. Recall the murder-suicide analogy.

Another argument against "showing the flag" on price when a potential new entrant's interest level rises is that even with a multi-year lag in building and equipping new production facilities, competitive surveillance may not discover a new entrant's interest in time to bluff him into cancelling his plans. Certain of the potential new entrant's management team would undoubtedly "lose face" in such a retreat and under such circumstances could not be counted on to act rationally. Again a mistake would be disastrous. Finally if the price were held above the Bain's limit price, with the intention of "showing the flag" when needed, the price may be sufficient to cause new entry into or expansion of the fringe, or high cost, competitors.

As Scherer (1980:247-48) summarizes, protecting market share with pricing policy requires a two-pronged strategy of deterrence.

> "Existing sellers hold down the price and increase output just enough to deter inefficiently small entry and fringe rival expansion or to optimize the rate of entry... (And) on the other hand, implicit or explicit threats of price warfare are brandished to deter entry at large, relatively efficient scales."

Effects of the experience curve on limit pricing

An extremely important consideration is the effect the Boston Consulting Group's experience curve has on the strategic implications of limit pricing. All previous discussion on setting a limit price to deter both fringe and large scale erosion of market share assumed that the cost functions of both the dominant firm and new and potential entrants were static over time. In fact, the effect of the experience curve is that relative costs depend on total accumulated production volume. And, if a limit pricing strategy is successful in deterring expansion, the dominant firm's experience will grow faster than his competitors. The dominant firm's cost advantage will grow and the rewards of a limit pricing policy will increase over time.

With respect to small scale competitors, if the firm's limit pricing strategy is effective the fringe will not expand and their cumulative production experience will grow linearly with time. If total demand is growing, the share supplied by the fringe will decline with time. Using the experience curve effect, the firm's costs will decline faster than that of the fringe and the firm's spread between the price required to limit fringe expansion and its cost will grow over time, thus magnifying earnings.

With respect to potential large scale competitors, if the firm's limit pricing strategy is effective the potential competitor will never enter the market. If the competitor's cost is truly a function of his cumulative volume, then the limit price will remain constant over time since the competitors' cost does not decline. The firm will see its margin and earnings growing quickly as costs fall and the limit price remains constant.

Perhaps a more reasonable case would allow for declining limit prices over time. Such would assume the potential large scale competitor's entry cost would fall over time even without actual production experience as a result of knowledge "leaks" out of the firm such as that with employee turnover, patent expiration, success at reverse engineering, etc. If so, the firm's margin and earnings would not grow as quickly as initially thought due to the falling limit price required to discourage large scale competitive entry.

Clearly, the effect of the experience curve on limit pricing are large and the implications for strategic planning are monumental. As Scherer (1980:251) summarizes:

> "It is conceivable that when learning-by-doing economics (i.e. experience curves) are important the capturing of an initial advantage by some company could set in motion a dynamic process that ends with the relevant product line more or less permanently monopolized."

When we integrate the capital investment decision process, i.e. net present value, into a limit pricing strategy, it becomes clear that the firm can control competitors' expansion plans, and therefore market share, if:

1. The firm understands how competitors view the future of the market, and
2. The firm prices appropriately, and
3. Competition understands the implications of the firm's pricing policy and acts rationally.

Competitors future expansion plans are determined as the firms are, by the financial attractiveness of the business investment proposed. Expected financial attractiveness is a function of the competitors':

1. Sales volume over time, which is determined by his forecast of the industry product life cycle and his market share.

2. Cost of sales over time, which is determined by his initial cost position and his forecast of sales volume from (1) above, which determines progress down the experience curve.

3. Sales revenue over time, which is determined by his forecast of sales volume from (1) above and market price.

4. Investment requirements.

5. His cost of capital.

If the firm sets the price, and sets a price policy for future prices, that just makes the net present value of the competitors proposed expansion equal zero, then the competitor would have no financial incentive to expand. The competitors' market share would decline over time as the firm continues to expand and as competing production facilities wear out or become obsolete. The firm might accomplish the same goal, i.e., no further competitive expansion, at a higher price, considering competitors capital rationing situation. Under capital rationing competitors would be unable to accept all positive net present value investment. Ideally then, if the firm knew all its competitors capital investment proposals and their resource availability, the firm could set a price higher than that which would yield zero net present value to competitors and still have the investment rejected by his management. Such a plan, while risky, might be a reasonable gamble, because any increase in market price that does not result in a deterioration of market share increases the net present value of the business to the firm.

The firm may wish to control its competitors actions in two other ways. The firm may wish to accelerate a competitor's progress toward zero market share, or the firm may wish competitors to maintain constant market share over time. Again, both results may be accomplished if the firm prices correctly and effectively use the "bluff" of business brinksmanship.

How can the firm encourage competitors to shut down existing production facilities? Clearly, the answer, as John D. Rockefeller demonstrated with his Standard Oil Trust, is low current prices and the expectation of continual low prices. If prices are so low that sales revenue is below cash operating expenses and such conditions are expected to persist, competing production facilities will be shut down. If prices are so set by a dominant firm with the intention of harming smaller competitors, then such predatory pricing has been declared illegal in the United States and many other Western industrial countries. It is however conceivable that the same effects might be accomplished without running afoul of antitrust laws. First, in a growing business, where experience curve effects are important, each production facility will likely have slightly different costs. Undoubtedly, the newest facility will have the lowest cost because it incorporates newer lower cost technology, and older facilities will have higher costs. Therefore a certain given low price will "pick-off" only the oldest, least efficient facility not the whole business of a competitor, assuming he is a multi-plant operator. Second, the observed result of predatory pricing that was found socially objectionable was the fact that prices were raised to monopoly levels once the competition was destroyed by predatory pricing. Again, early in the product life cycle, where market share gains are most worthwhile, cost can be expected to fall dramatically thus disguising the price effects of more monopoly power. The key to getting a competitor to shut down a production facility is to convince him that the lower prices are permanent, at least as long as that facility remains in production.

How can we encourage a competitor to maintain constant market share over time? In a growing market a competitor must find expansion financially attractive to maintain market share. How can we price to give him positive present value, but still discourage him from trying to gain market share? The answer must lie in developing a feeling by the competitor that he is a member of the "club" supplemented by a believable threat of punishment if he upsets established relationships.

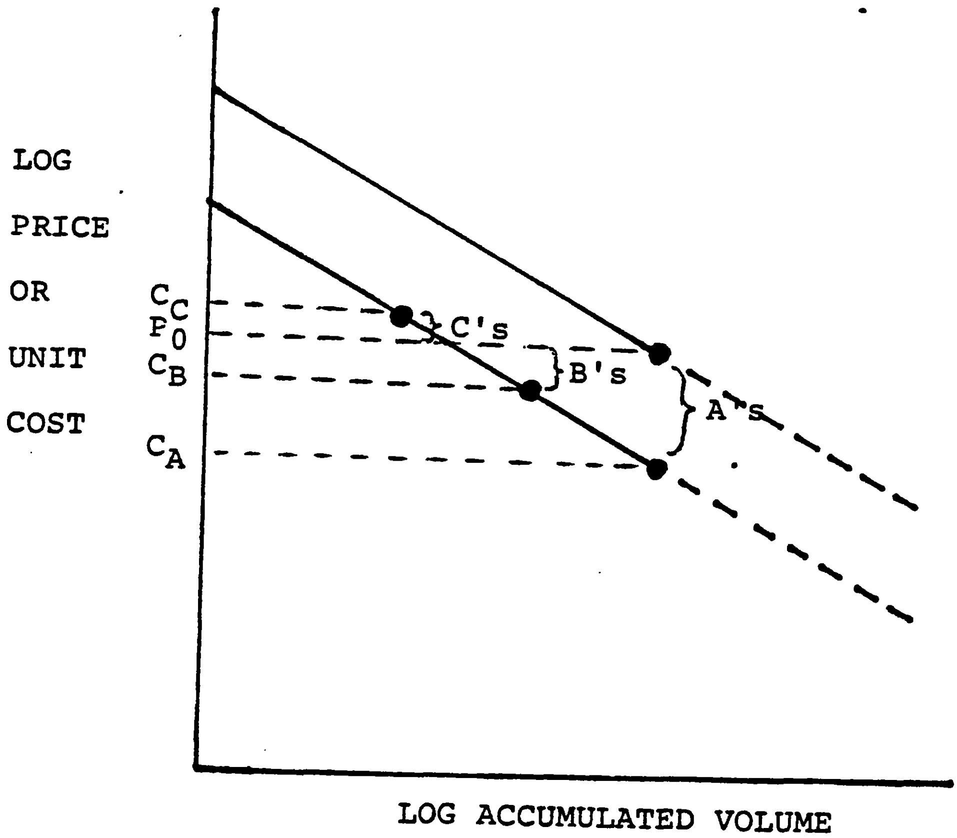
The multi-competitor case

So far, all discussion involved at most one other competitor. More generally, there are multiple viable competitors in each business. Multiple competitors tend to make business relationships more unstable. The instability makes the calculation of the benefit to the firm of investing in a business much more dependent on accurate estimates of how each competitor will react to the firm's strategic moves.

Recall, a main assumption of the limit pricing theory as so far discussed was that the firm could control the actions of its competitors by proper pricing. When the firm developed a new product it could set prices to discourage other competitors from entering the market. And when the firm attempted to increase share, it set prices low enough to discourage the competitor's expansion or encourage his withdrawal from the market. Such pricing strategies can logically be calculated from a knowledge of the competitor's economics and the application of net present value techniques. However, when there are multiple competitors, it is likely they will have different economics and one price strategy will not affect all competitors the same.

Figure 3-12, below, shows the general case of multiple competitors. Points on the Price/Cost axis C_A, C_B, and C_C represent the cost for Firm A, B, and C, respectively, and point P_0 represent the price in effect at that point in time as related to Firm A's cost. The unit profit margin, before tax, can be read as

FIGURE 3-12. LIMIT PRICING WITH MULTIPLE COMPETITORS



the difference between price and cost on the graph as:

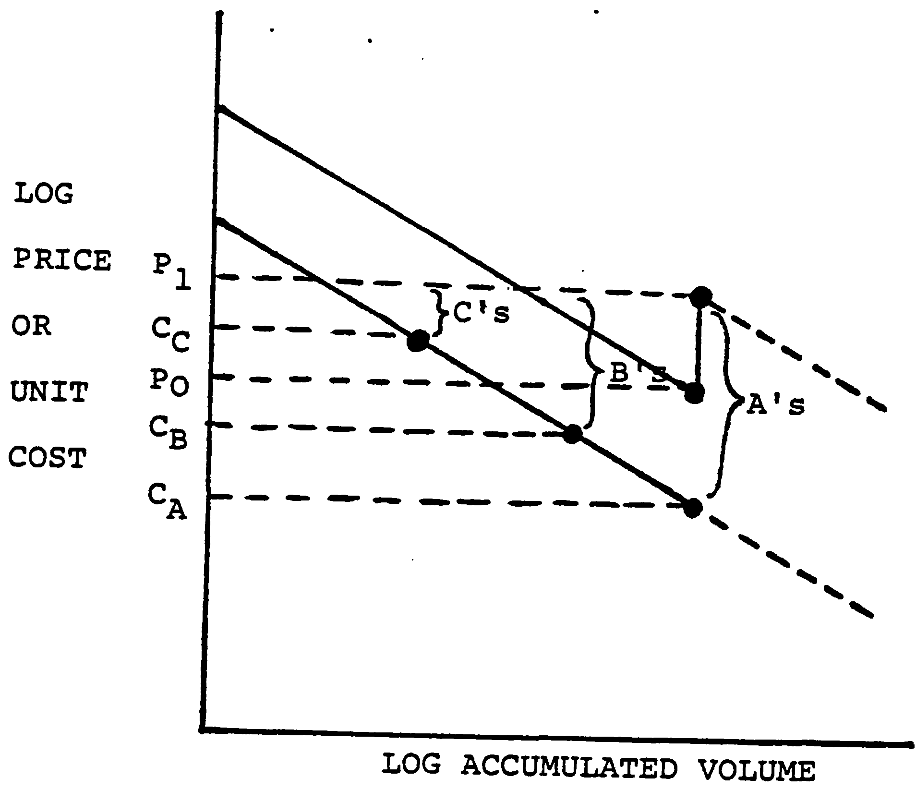
FIRM	UNIT PROFIT MARGIN
A	$P_0 - C_A$
B	$P_0 - C_B$
C	$P_0 - C_C$

Firm A's profit margin is relatively large, B's is relatively small, and C's is small and negative. Assuming Firm A is the price leader and all firms view the market as Firm A does, what message would such a pricing policy by A give to firms B and C? If Firm C expected the price to continue to follow the price line shown in Figure 3-12, and he could not justify an investment in increased market share, his loss position would discourage him from any expansion and would eventually guarantee his withdrawal from the market. Firm C's loss of market share would be taken up by either Firm A or B. However, Firm B's small profit margin might not be sufficient to justify an expansion of market share and Firm A may not wish to expand its share or it fears antitrust or other problems if it further dominates the market.

If Firm A raises the price from P_0 to P_1, as shown in Figure 3-13, on the next page, it will give a profit margin to Firm C, calculated to encourage him to expand with the market and maintain his market share. Firm B, however, will now have a large profit margin and may be encouraged to attempt to increase his market share. Firm A must be willing to give up market share to Firm B to keep Firm C growing with the market. Firm A may be unwilling to lose share, particularly if he felt his market share was financially optimum. Clearly, Firm A's control over price may not be enough to control the actions of all competitors, without further strategic moves.

Note from Figure 3-13 that if Firm A raised the price to P_1 from P_0, both Firm A and B would increase their profit margin and total profit, if demand were inelastic. If Firm B would not use his increased

FIGURE 3-13. THE EFFECT OF HIGHER PRICES



profitability to expand his market share, Firm A's goal of maintaining the current shares of each competitor could be satisfied, as well as profits increased. How could Firm B reasonably be expected to restrain from attempting to increase share? The answer may be in what the Henderson (1979) calls "business brinksmanship". Suppose Firm A told Firm B of its goal of maintaining current market share and the need for higher prices to keep Firm C in business. Further, suppose Firm A told Firm B that if B used its increased profitability to attempt to gain market share, A would abandon its goal of keeping Firm C in the market and would start a price war to punish B.

Perhaps such a threat would deter B's expansion, perhaps not. In any event, such collusion is clearly illegal in most industrialized countries under antitrust laws. It is clear though that as the number of competitors expands, the ability of the market leader to control competition deteriorates. The implications for this model are important. Without the ability to control competition, the calculation of the financial attractiveness of investing in an SBU becomes highly uncertain, primarily due to speculation about how various competitors may react. For that reason, I have elected to limit the model to a two participant market-- the firm and one competitor.

From the perspective of the firm, though, the implication seems clear. Unless the firm can control competition over the product life cycle, its ability to enjoy monopoly power will be limited and the likelihood of price warfare will increase. The value of investing in such an SBU, while not exactly calculably, will clearly be less than it would otherwise have been. Therefore, it seems logical that an SBU with at most one viable competitor is more valuable to the firm than an SBU with multiple viable competitors.

CHAPTER 4

THE MODEL

In Chapter 3, "The Conceptual Framework", I attempted to show that the tools of the product life cycle, the experience curve and limit pricing might be useful to develop a model to measure the financial attractiveness to the firm of investing in current or potential SBU's.

This chapter's goals are to integrate fully those tools into a quantitative model and to:

* Outline the "standard" assumptions on which this thesis' computerized model operates.

* Define the assumptions used to calculate incremental cash flows and net present value.

* Use those assumptions in an abbreviated case study to demonstrate the mathematical relationships of the model.

INTEGRATION OF THE TOOLS

It is the contention of this thesis that by combining the tools of the product life cycle, the experience curve and limit pricing, into the capital budgeting framework of discounted incremental cash flows, the strategic implications of investing in SBU's can be taken into account and the financial attractiveness of such investments can be quantified and therefore ranked.

Perhaps the simplest way to demonstrate that integration is to begin by reviewing the McKinsey portfolio matrix. Recall that matrix measures "industry attractiveness" horizontally and "business strength" vertically. It assumes that an SBU judged "high" along each axis, i.e. in the upper left-hand block, is attractive and therefore the firm should invest in that SBU.

Quantitatively, what makes an industry attractive to the firm? From the capital budgeting standpoint, profits should be high relative to the investment required and the industry should have a long remaining life so to enjoy those large positive cash flows made possible by high profits. In simple terms, that means a business early in its life cycle (i.e. with high growth rates) that the firm has the ability to dominate (i.e. the firm has a degree of monopoly power perhaps through high market share). It also certainly helps to be in a business that others find unattractive.

Quantitatively, what measures a firm's business strength in particular industry? Basically, it must be how efficient it is in bringing the goods or services to the market (i.e. the slope of its experience curve relative to competition and initial starting positions) and how able it is to invest the resources required to maintain its monopoly power in its business, if selected.

Therefore, in a dynamic sense, an SBU is most attractive for investment, i.e., extra capacity has a high net present value, if:

* It is early in a long product life cycle.

* Competitors find the business unattractive and can be discouraged from further investment by appropriate limit pricing.

* The firm has an initial cost advantage through experience and the ability to reduce cost with experience at least as quickly as competitors.

* The firm must have the resources available and the commitment to use those resources to take and maintain a dominant position.

Conversely, the firm will find an SBU unattractive if competition views the market as much more attractive or if the firm is unable to become a "world class" level competitor in that market, given its starting position in the product life cycle and its experience curve slope.

Therefore, this model proposes that the financial attractiveness to the firms of investing in a current potential SBU is a function of:

1. The firm's estimate of the current position in the product life cycle and its forecast of the subsequent shape, size and length of the remaining product life cycle.

2. The competitor's forecast of the shape, size, and length of the product life cycle.

3. The firm's initial cost position on the experience curve and the rate it can reduce cost through experience.

4. The competitor's initial cost position on its experience curve and the rate it can reduce cost through experience.

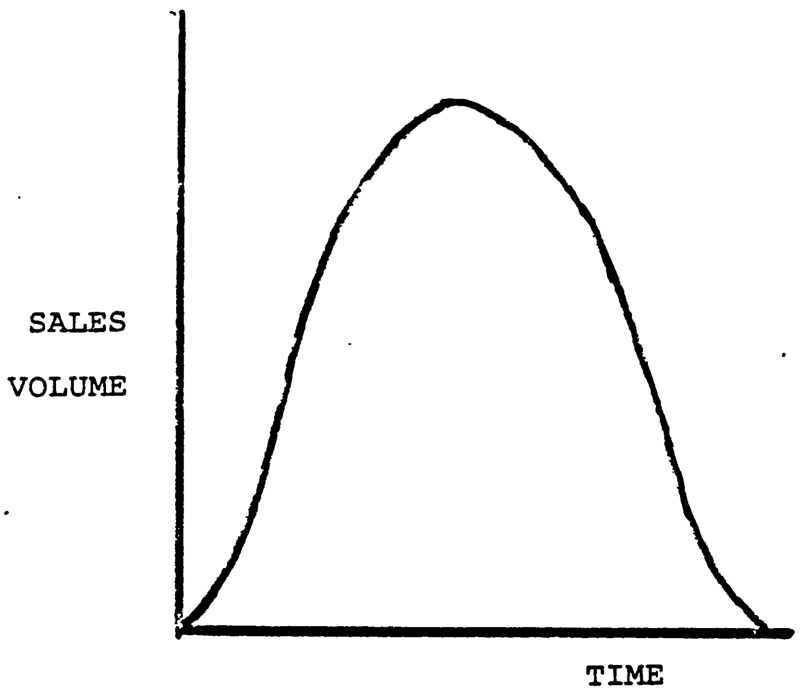
all assuming the firm has the resources available and the commitment to use those resources to maintain a dominant position in the business throughout its life cycle.

For further work, it is assumed that such resources and commitment are available. However, let's consider the conditions under which resources may not be available. A firm may not invest in an otherwise very attractive opportunity if the ultimate size of the market is either too large or too small relative to the size of the firm, as measured by the firm's forecast of its product life cycle. If the market is too large, the resource commitment required of the firm to maintain a dominant position may exceed its total resources, or may be so large relative to its total resources as to make the firm unduly risky. If the market is too small, the business by definition fails to fit the overall plan of the firm, most likely because the potential reward does not merit even minimum top management attention. Such considerations, while important in determining when investment is feasible for the firm, do not directly affect the calculation of the financial attractiveness of the investment; and are therefore set aside.

At this point, it is appropriate to describe in some detail exactly how the tools of the product life cycle, the experience curve and limit pricing combine to measure the net present value of investment in an SBU. For the sake of simplicity assume: (1) only two participants in the business, the firm and a competitor; (2) no uncertainty about the future; and (3) each competitor is motivated solely by net present value. The following example is qualitative rather than quantitative. A quantitative presentation is given in a subsequent subsection entitled, "Model Logic".

Since the model is market-oriented, it must begin with both participants' forecasts of the product life cycle. Assume it is as shown in Figure 4-1, for both participants and that the firm is aware of the competitor's estimate.

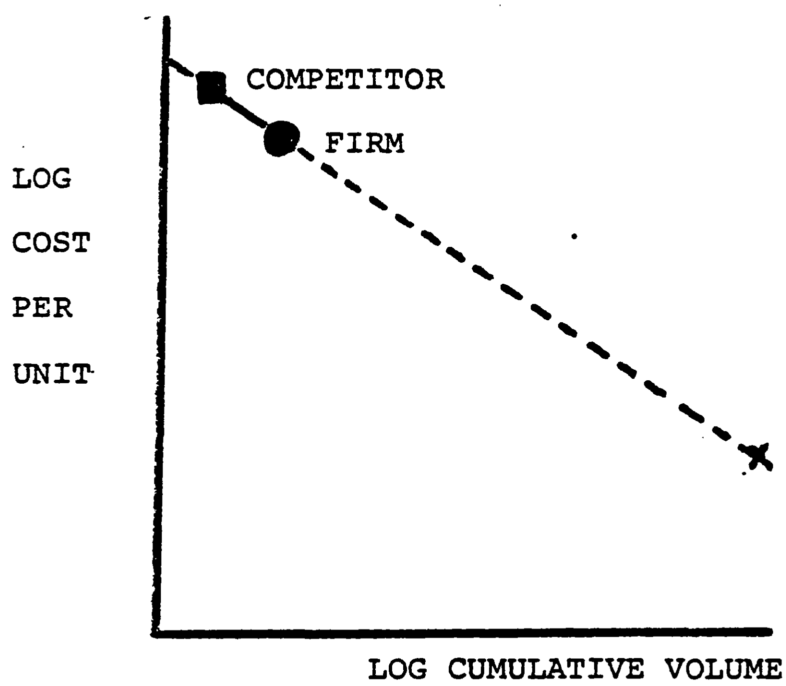
FIGURE 4-1. FORECAST PRODUCT LIFE CYCLE



Naturally, it is possible, even highly likely, that both participants' views of the market's future will vary in size, shape, and length. The financial effect of such different perceptions of market attractiveness are very important and are addressed in the next chapter entitled, "Mapping Results".

Given a forecast of the product life cycle, the current cost position of both participants (assumed to be based on each accumulated volume) and a measure of the competence of both participants as a competitor (assumed to be the slope of each experience curve), it is possible to forecast relative cost positions throughout the product life cycle. Assume that the firm has had a dominant market share in the past and therefore a lower current cost than the competitor and the both participants have experience curves of equal slope as shown in Figure 4-2:

FIGURE 4-2. FORECAST EXPERIENCE CURVES



Relative cost positions of both participants along the path for future cost decline are determined by the accumulated volume of each, which is again determined by their initial cost position and the relative market share over the remaining product life cycle. To proceed, the firm must decide how it will manage the business. Its options are: gain market share, maintain market share, or lose market share. Let's assume the firm selects to gain market share, without any consideration yet about whether or not that is an optimum or even good strategy. There are basically two ways to gain share: either take a larger portion of future growing sales by adding capacity quicker than the competitor, or taking all sales, current and future, by driving the competitor out of the business. The former involves discouraging the competitor from making investments in additional capacity. The latter involves making the economics so unattractive that the competitor shuts down his existing plants. Let's assume the firm selects to gain market share by taking all future sales by discouraging additional investment by the competitor, without any consideration yet about whether or not that is an optimum or even good strategy.

With those assumptions it is now possible to calculate both competitors' costs each year over the entire product life cycle as shown in Figures 4-3 and 4-4, on the next page. Note, because the firm plans to increase market share, its costs will always be lower than the competitor's and the cost difference will grow over time.

How can the firm manage the business so that the cost patterns described in Figures 4-3 and 4-4 are achieved? Since they were calculated assuming the competitor never expands his capacity, the firm must price to discourage competitive expansion. In financial

FIGURE 4-3. THE FIRM'S FORECAST COSTS

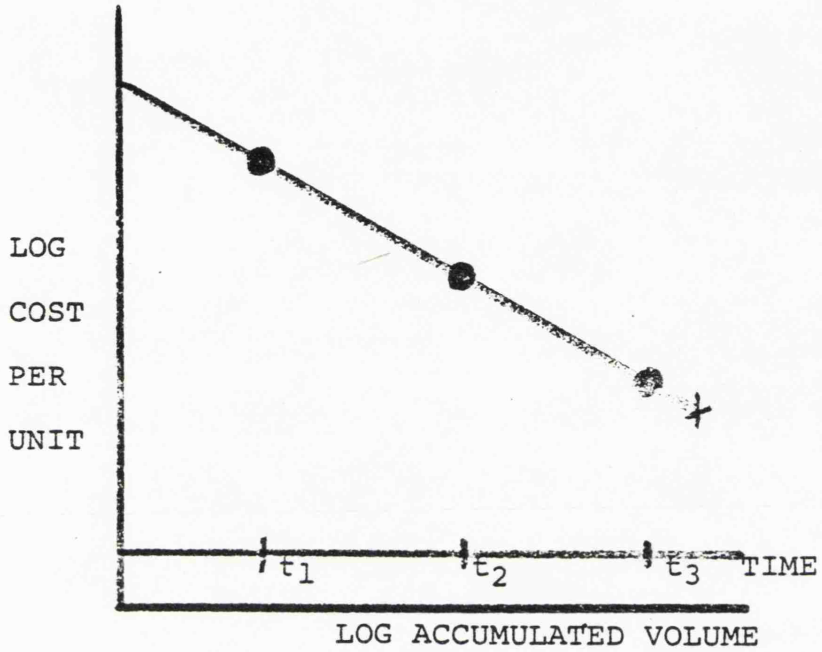
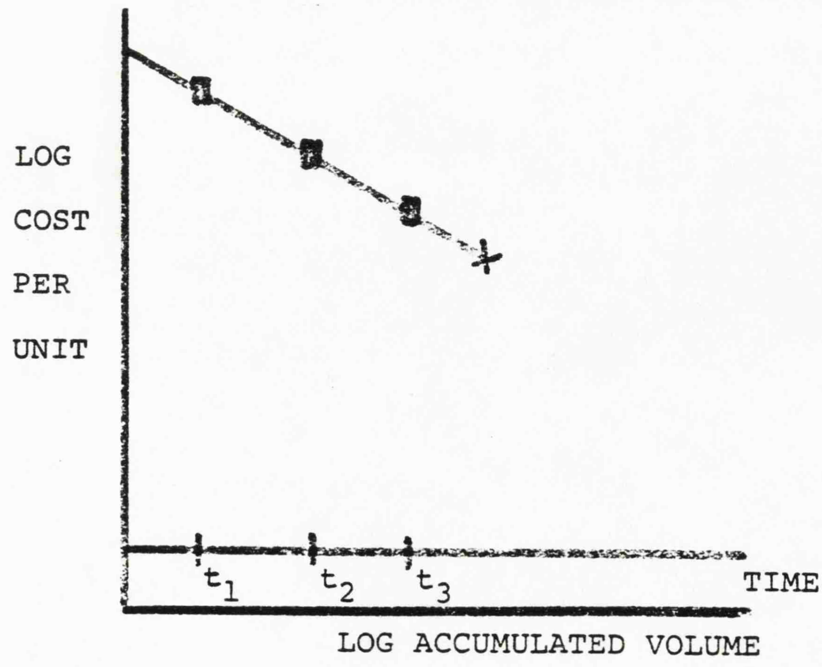


FIGURE 4-4. THE COMPETITOR'S FORECAST COSTS



terms, that means the net present value to the competitor must be at most zero. However, recall that such decisions are based on incremental cash flows, that is the difference between expanding and not expanding. Figure 4-4 shows the competitor's cost position is he fails to expand. Would it differ if he did expand? Of course! Costs would be lower each year with increased market share. Are there any other incremental effects? Yes! Volume would be clearly higher with increased share and, more subtly, since the competitor's cost penalty versus the firm would be less, he could also expect a higher market price. Figure 4-5 summarizes the incremental economics to the competitor:

FIGURE 4-5. COMPETITOR'S INCREMENTAL ECONOMICS

INCREMENTAL EFFECT ON	IF	COMPETITOR EXPANDS TO MAINTAIN SHARE	VS. IF	NO EXPANSION
Volume		High		Low
Cost		Low		High
Price		High		Low

Certainly, the competitor's incremental economics favor expansion is most cases unless the price is quite low.

But, at some price, say zero for example, the competitor will not find expansion attractive if he believes that price will persist.

The theoretically correct price to set to assure the cost patterns described in Figures 4-3 and 4-4 is the price, or more exactly the price pattern over time, that yields the competitor a zero net present value on his incremental cash flow. The question of the proper price pattern versus a single year's price deserves more comment. Given the firm has perfect knowledge about the competitor's costs and investment requirements over time, there is an infinity of price patterns that will yield him zero net present value. As an example, assume the competitor's costs* are as shown in Figure 4-6, on the next page, and for simplicity there is no investment requirement for capacity expansion.

If the price the firm set was exactly the same as the competitor's costs, net cash flow would be zero each year and at any discount rate net present value would also be zero. However, the firm could set a price and maintain it constant over the product life cycle as shown in Figure 4-7, also on the next page.

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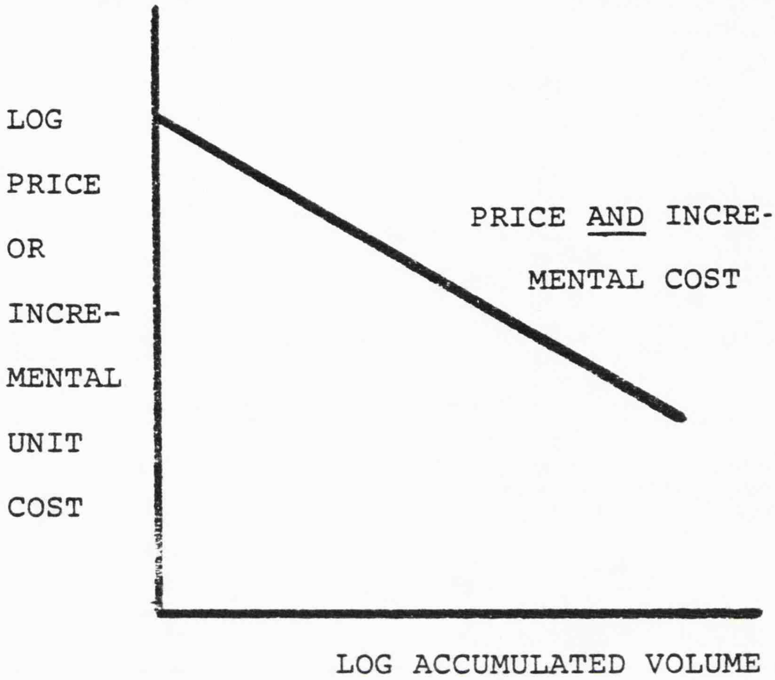
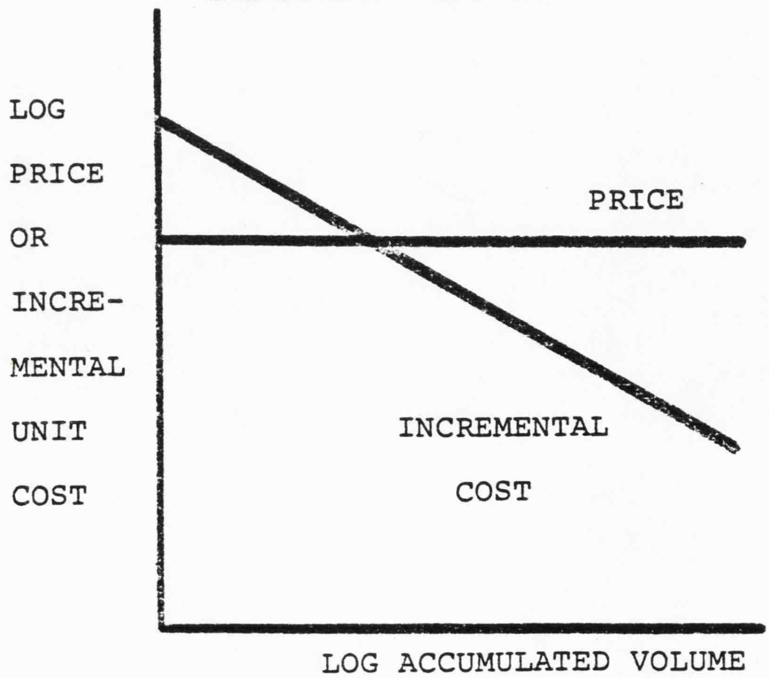
*Note costs are incremental based on the difference between expanding with the market versus not expanding.

FIGURE 4-6. THE COMPETITOR'S INCREMENTAL COST



The location of the constant price line, in this example, would depend on the competitor's cost of capital.

FIGURE 4-7. CONSTANT PRICE TO GIVE ZERO NET PRESENT VALUE



Since there is an infinity of possible price patterns, which shall the firm choose to discourage the competitor's expansion? I believe the most important factor to consider in the selection is to pick that one that is most believable and understandable to the competitor.

Let's consider two possible patterns that would not qualify on that basis. Pattern 1, assume, is a very high initial price with the expectation that prices decline faster than costs. The competition may well see the initial high price and disregard the threat of rapidly falling prices to justify investment. As Scherer (1980:247) says,

> "the (competitor) is likely to read the current price...as some sort of a 'statement of future intentions.'"

Thus the strategy might fail to discourage expansion not because it has theoretical faults but because it is misinterpreted by competition.

Pattern 2, assume, is a very low initial price with the expectation that prices will rise as costs falls. The competitor may well see the initial low price as nothing more than a scare tactic that he can disregard. If the competitor understands the experience curve, he will have a good estimate of the firm's costs and by comparing that to the very low market price he will know the very low price can only be temporary and prices must go up. He may suspect prices will go high enough to justify expansion. As Scherer (1980:246) says,

> "the threat...lacks credibility, and threats that are not credible do not deter."

Again, the strategy may fail to discourage competitors.

What price is most believable and understandable to the competitor? I am not sure that question can be answered with certainty! It surely depends on the psychological make-up of the competitor's top management, as well as the firm's past pricing policies that condition competitors about what to expect. To proceed with the model, I do need to make a price pattern proposal.

In this case I elect to follow the Boston Consulting Group's (1968: 8-11) recommendation, that is that prices will follow the lowest cost producer's costs, that is, prices will be related directly to the firm's costs, perhaps by a constant percentage mark-up. However, from the competitor's perspective, since the cost differential is widening as he loses share, the competitor will see gradually declining profit margins over time. That pattern is shown in Figures 4-8 and 4-9, on the next page. The price pattern makes intuitive sense as well as paying the dividend that it would make it difficult to prove predatory pricing in an antitrust complaint.

FIGURE 4-8. THE PRICE/COST PATTERN AS VIEWED BY THE FIRM

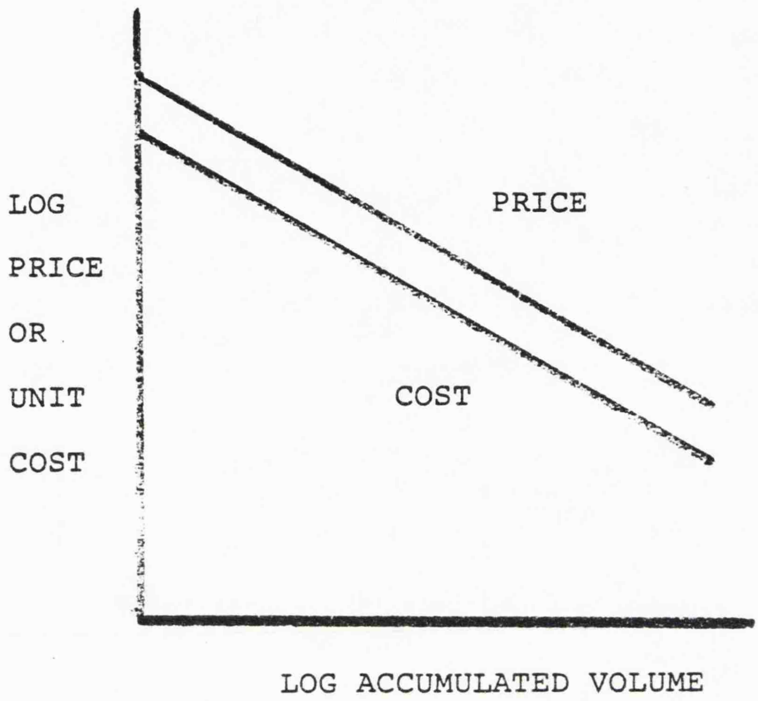
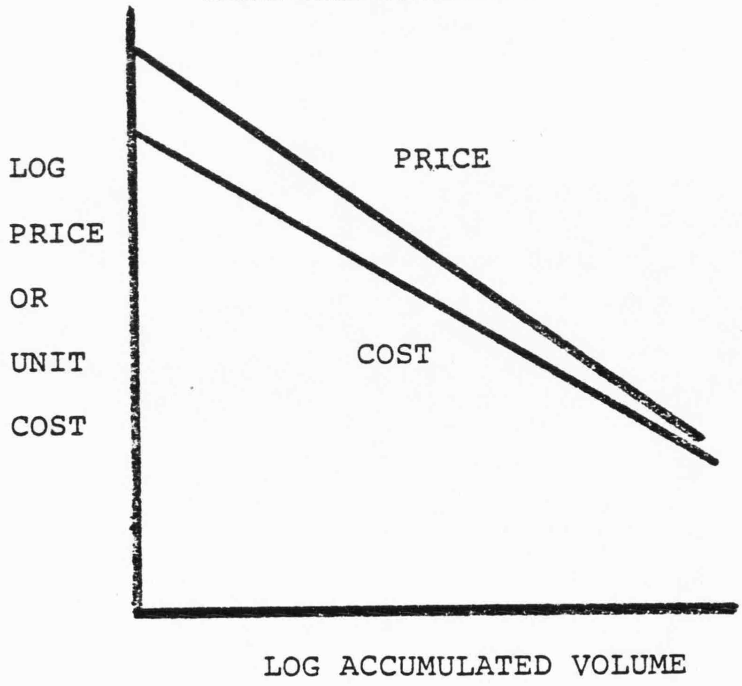


FIGURE 4-9. THE PRICE/COST PATTERN AS VIEWED BY THE COMPETITOR

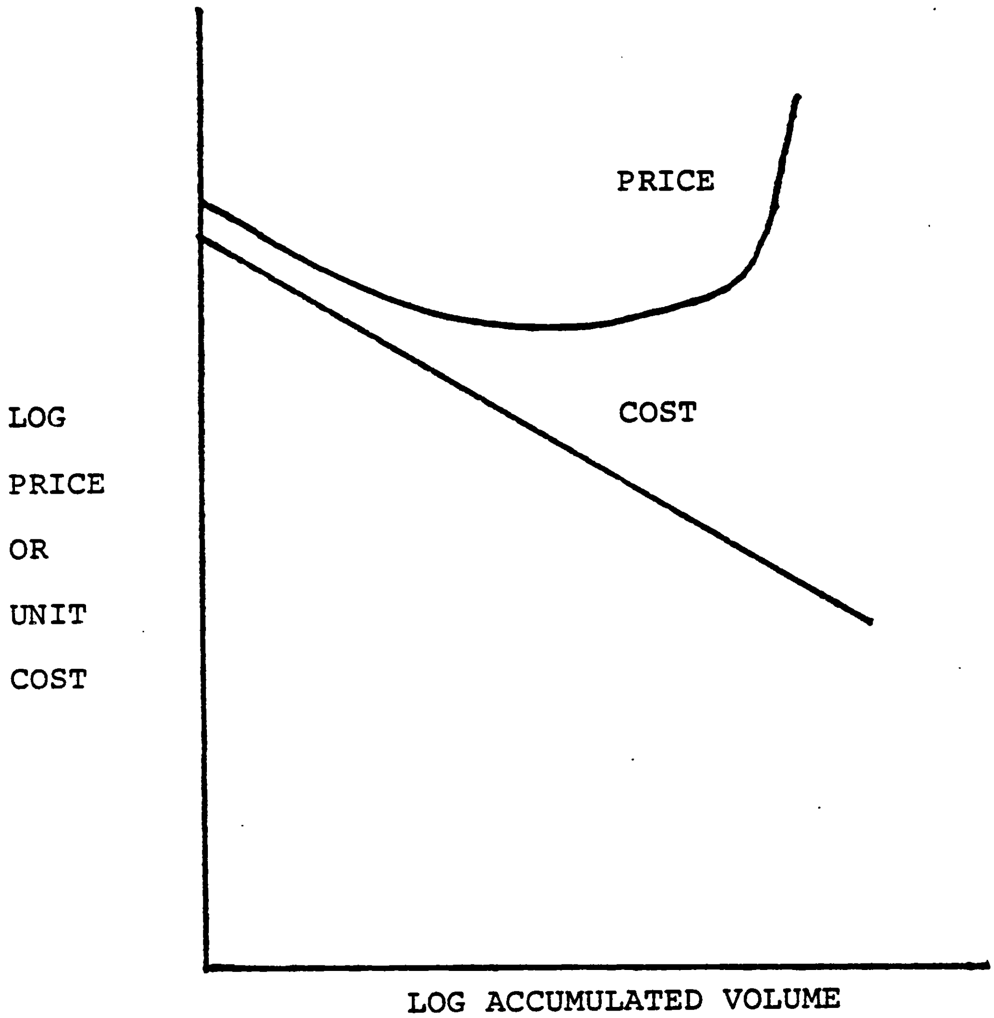


Capital budgeting decisions are made at discrete points in time. To achieve the cost positions originally shown in Figure 4-3 and 4-4, the firm must discourage competitive expansion at each point in time. Assume temporary success! The firm has made the investment required to satisfy market growth, the competitor has failed to expand, and the firm has increased market share. What changes over time? Basically two things: the firm's cost advantage over the competitor is larger and the product is closer to the end of its life cycle.

Temporary success in discouraging competitive investment makes the job of discouraging him in the future easier. New conditions will allow a higher price, or more precisely a higher price pattern, because the business is basically less attractive to the competitor as his cost disadvantage widens and time left to "enjoy" the market is shortened. The effect over time on the firm is as shown in Figure 4-10, on the next page.

Instead of a market price paralleling the firm's cost, prices will gradually diverge from cost, increasing the firm's margin. At the limit, just prior to the end of the product life cycle, the numbers will indicate the competitor will not invest even at extremely high prices. However, the market price cannot go to extremely high levels in practice due to competition from substitute products. As shown in Figure 4-11, on the second following page, at some point the firm will have established an unchallengeable position with respect to

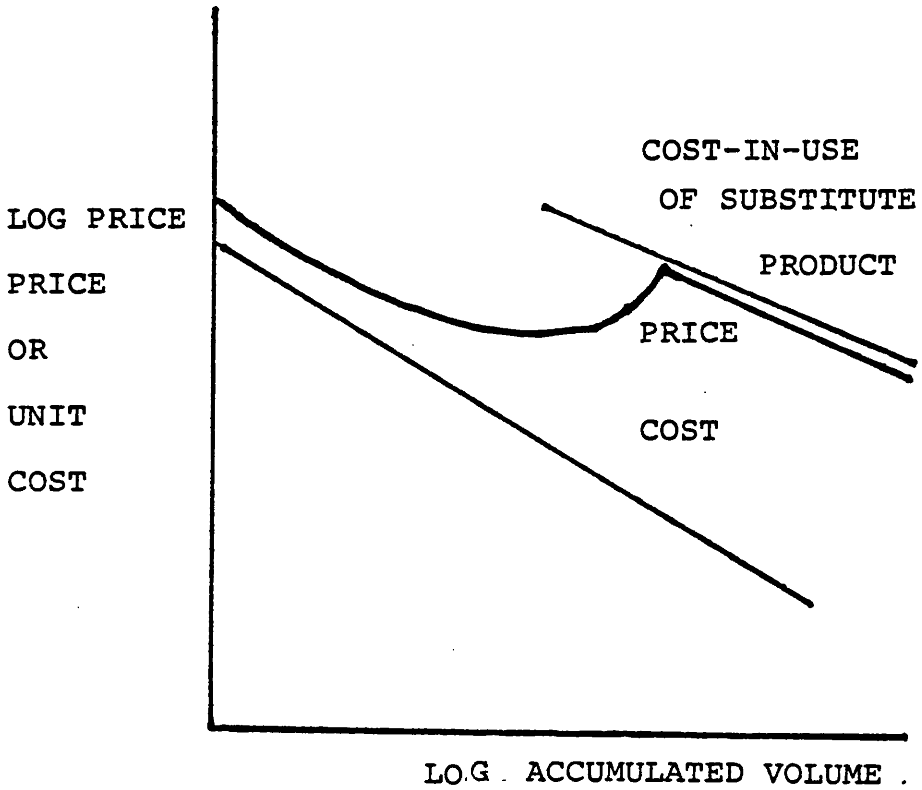
FIGURE 4-10. ACTUAL PRICE/COST PATTERN WITH SUCCESS BY THE FIRM IN DISCOURAGING COMPETITIVE EXPANSION



the competitor and the only restraint on prices will come from the cost-in-use of those substitute products.

Early in this section, it was assumed that the strategy to follow was to expand market share by discouraging competitive investment. The model is now able to calculate the financial attractiveness of that strategy to the firm by calculating the net present value of the incremental cash flows of expanding share as

FIGURE 4-11. ACTUAL PRICE/COST PATTERN CONSIDERING SUBSTITUTE PRODUCTS



proposed versus not expanding share, calculated in a similar manner. This net present value can then be compared with the best strategy for the firm to follow in this SBU. If gaining share is a good strategy, the firm might then test if it yields superior results to set prices to drive the competitor out of the business.

The capital budgeting decision has been fully integrated into the strategic decision in the sense that any decision to acquire assets or not to, can now be considered directly as a decision to increase or maintain share or perhaps to let share fall.

MODEL ASSUMPTIONS AND LOGIC

The previous section, "Integration of the Tools", showed in a qualitative way how the tools of the product life cycle, the experience curve and limit pricing can be combined to quantify the benefits to the firm of a change in its strategy for the management of an SBU. Recall, the essence of a strategy for the management of an SBU involves a decision regarding adjustments to the firm's market share. Since adjustments to market share obviously have capital budgeting implications, then if handled correctly, strategic planning and capital budgeting theory are fully integrated in the model, and the firm is able to determine how each SBU should be managed and how "profitable" (as measured by net present value) that management strategy will be.

The goal of this section is to (1) quantify the model by defining the "standard" assumptions used regarding the product life cycle, the experience curve and limit pricing, (2) to define the assumptions used to calculate incremental cash flows and net present value, and (3) to demonstrate the model's logic by a simplified example.

Naturally results will be heavily influenced by the "standard" assumption made about the product life cycle, the experience curve and limit pricing, as well as the many assumptions made in the quantitative model about the calculation of incremental cash flows and net present value. It is therefore <u>not</u> the contention of this thesis that the quantitative output of this model is universally applicable to real world business conditions. It is however applicable to the "standard" assumptions made; and it is most definitely a theoretical framework in which real world assumptions particular to each firm, its product, its competition and its technology can be input to yield meaningful measures of the financial attractiveness of further investment in (or adjustment to the market share of) existing or potential SBU's.

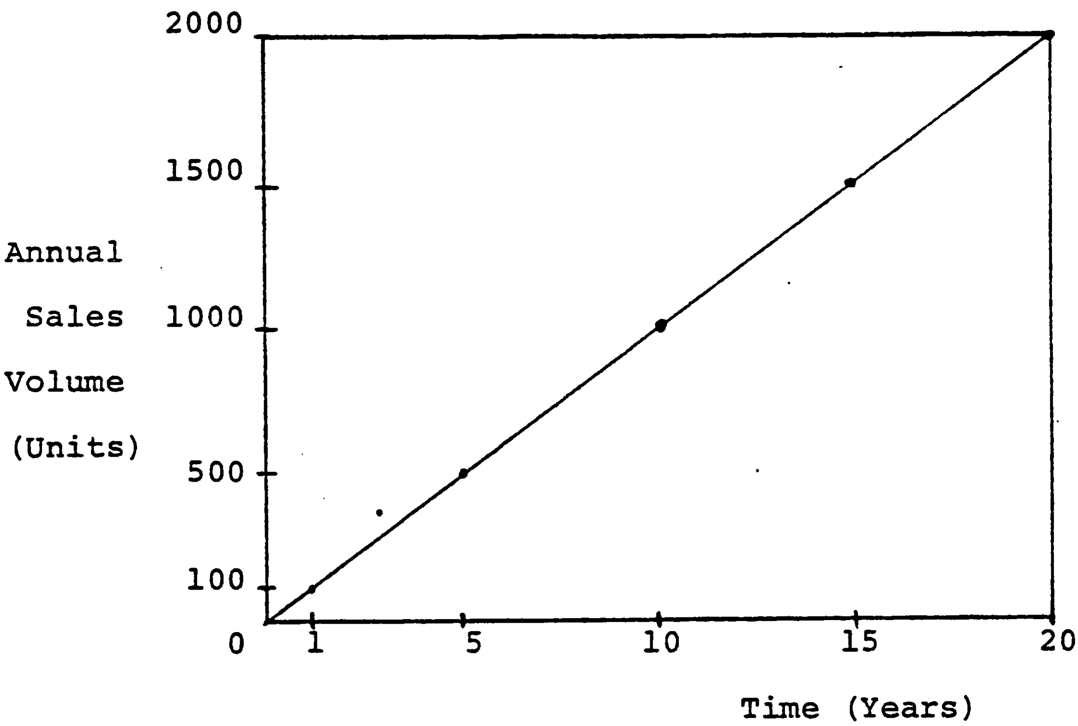
To understand the model output and its implications, as described in the next chapter, it is important to understand the input to the model -- both the "standard" assumptions on product life cycle, the experience curve and limit pricing, and the many assumptions required to calculate incremental cash flows and net present value.

<u>"Standard" assumptions</u>

To proceed, the firm must understand its market and be able to define the product life cycle over time as a function of market price. Normally, the product life cycle will be bell-shaped and will include a declining phase as well as an ascending and maturity phase. For computational simplicity, I have elected an ever ascending product life cycle of twenty years length, declining to zero after year twenty. Such a sales pattern is essentially one-half of a stylized triangular product life cycle. Importantly, a product life cycle without a declining phase will allow me to test the investment recommendations of the Boston Consulting Group's growth -

share matrix, which as described by BCG allows for no declining sales. Figure 4-12 defines the assumed product life. cycle for the purpose of this model. Naturally any length, size and shape product life cycle could be substituted to represent real world conditions.

FIGURE 4-12. STANDARD PRODUCT LIFE CYCLE



For clarity, Figure 4-13, on the next page, lists in tabular form the product life cycle portrayed graphically in Figure 4-12.

The firm must also understand how its competition views its market. The logical way to proceed would be for the firm to define exactly how it believes competition sees the market in terms of length, size and shape.

FIGURE 4-13. "STANDARD" PRODUCT LIFE CYCLE IN TABULAR FORM

YEAR	ANNUAL SALES VOLUME	YEAR	ANNUAL SALES VOLUME
1	100	11	1100
2	200	12	1200
3	300	13	1300
4	400	14	1400
5	500	15	1500
6	600	16	1600
7	700	17	1700
8	800	18	1800
9	900	19	1900
10	1000	20	2000

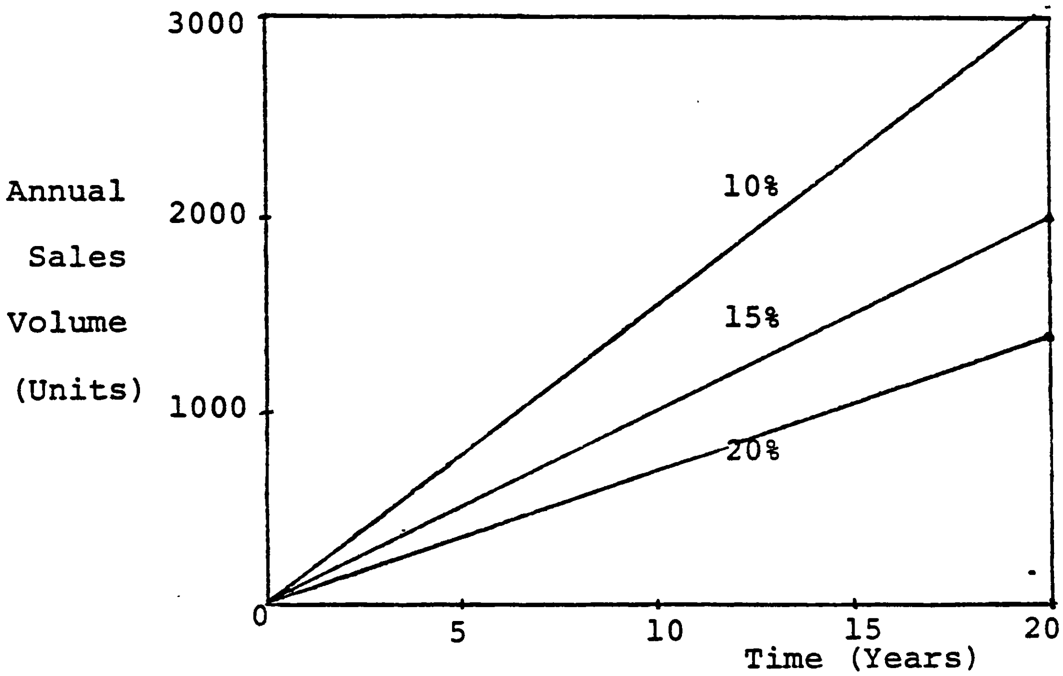
Naturally, competition may view the market as substantially different than the firm in terms of length and/or size and/or shape. As we shall see quantitatively later, such differences significantly effect the firm's economics.

For modelling purposes, I have elected to treat the subject of competition's view of the product life cycle differently than simply varying length, size and shape. Reasons for the change include both simplified calculations and standardization. I have elected to assume that both the competition and the firm view the market's length and shape as being twenty years and triangular, respectively. With that restriction, the only difference possible is in size (i.e. ultimate height of annual sales). Such restrictions allow the competitor's views of the product of life cycle to be expressed in terms of a variable required rate of return on his investment for future expansion, as viewed from the perspective of the firm, and using as a reference, the firm's view of the product life cycle.

As an example, if the firm's cost of capital is 15%, then its minimum required rate of return on investment on future expansion in the SBU must be 15% to assure at least a zero net present value. Similarly, if the competitor views the market exactly as does the firm and its cost of capital is also 15%, then, too, the competitor's minimum required rate of return is 15%. However if the competitor sees the market as more attractive than does the firm (i.e. considering the before mentioned restrictions, the competitor sees higher ultimate sales) the competitor will appear to the firm to invest at a lower required rate of return than its cost of capital. Clearly, the opposite is true if the competitor views the market as less attractive than does the firm, both assuming the firm and the competitor have equal capital costs.

Figure 4-14, on the next page, shows three examples of the product life cycle estimates by the competitor, each expressed in terms of ultimate sales and competitive required rate of return, assuming equal length and shape:

FIGURE 4-14. PRODUCT LIFE CYCLE SIZE VS.
COMPETITIVE REQUIRED RATE OF RETURN



Exactly how is the ultimate size of the product life cycle related to the competitive required rate of return as viewed by the firm? Given the firm's estimate of the product life cycle as shown in Figure 4-12 and assuming a 15% cost of capital, then as shown in Appendix 2, the summed discounted value of all sales over the product life cycle is 4581.8 units. At a 10% discount rate (or competitive required rate of return), the summed discounted value of all sales is 7031.3 units -- a 53.5% increase. Assuming, as I have, that both ends of the product life cycle (i.e. the beginning of year zero and the end of year twenty) are pinned to zero sales and the shape is triangular, the ultimate height must rise from

2000 units in Figure 4-12 to 3069 units as shown in Figure 4-14, a 53.5% increase. Similarly, at a 20% discount rate (or competitive required rate of return), the summed discounted value of all sales is 3193.1 units -- a 30.3% decline. Therefore, the ultimate height must fall from 2000 units to 1394 units as shown in Figure 4-14.

In this model, I have varied the size of the product life cycle as viewed by the competitor, using the surrogate of the competitive required rate of return, as shown in Figure 4-15, on the next page.

Complicated as the use of the surrogate, "competitive rate of return", seems, after much thought I have concluded that the benefits of better defined standardization and simplification of computation outweigh the "cost" of seeming complexity and loss of general applicability. Naturally, if the real world demands it, any length, shape and size competitive product life cycle could be substituted in the model with minor adjustments, and no loss of theoretical accuracy.

The third major variable -- beyond how the firm and the competition view the product life cycle -- is how able the firm is to bring its product or service to the market efficiently, when compared to competition. As previously discussed, this "business strength", as McKinsey might call it, can be measured by the firm's initial cost position (determined by past accumulated volume) and its ability to reduce cost over time

FIGURE 4-15. REQUIRED RATES OF RETURN

FIRM	COMPETITION
15%	0%
15%	5%
15%	10%
15%	15%
15%	20%
15%	25%
15%	30%

(determined by the slope of the experience curve). For modelling purposes, I have elected to vary the slopes of the experience curves for both the firm and a competitor as shown in Figure 4-16, on the next page.

As already mentioned, I have elected to follow The Boston Consulting Group's position on the experience curve. As BCG (1968:1) says:

> "...costs appear to go down on value added at about 20-30% everytime product experience doubles."

I have simply decided to expand the possibilities to include a 15-35% cost reduction to further test the implications.

FIGURE 4-16. EXPERIENCE CURVE SLOPES

FIRM	COMPETITION
75%	85%
75%	80%
75%	75%
75%	70%
75%	65%

Two further assumptions are made necessary in the model if costs do decline as quoted. First, the model assumes that the "normal" slope of the experience curve for the firm is 25%, the mid-point of the 20-30% range given by BCG. Naturally, if actual conditions demand it, any other experience curve slope could be substituted. Second, the model assumes that all costs, not just the cost of value added, decline with experience. This assumption implies that the firm adds the entire value to the product as would an oil company who discovers, transports, refines, and markets petroleum products. Or, it assumes that if the firm does not add all the value (i.e. it makes purchases), then both the firm and its suppliers are effectively on the same experience curve, as might be a computer company making personal computers and purchasing related keyboards and display monitors. If neither of those assumptions are valid in a particular case, it would be easy to break down costs into the cost of value added by the firm and the costs of materials purchased, and use separate experience curves for each to calculate total cost declines as a function of time.

Three final factors effect the firm's net present value of further investment in an SBU -- the current position in the product life cycle, the initial share positions of the firm and competition, and the initial cost position of the firm relative to competition. The current position in the product life cycle is, I believe, what BCG really had in mind for the growth axis on their familiar Growth-Share matrix. Clearly, growth varies across the "standard" product life cycle used in this model and shown in Figure 4-12. Sales in year two of 200 units is a 100% growth from year one sales of 100 units. Sales in year three is a 50% growth from year two sales, etc. The model continuously varies the assumption about the initial position in the product life cycle while holding the other variables -- the length, size and shape of the product life cycle as viewed by both the firm and competition and the relative slopes of the experience curves -- constant.

The initial share position of the firm and its competition is very important in determining the financial attractiveness of further investment in an SBU, as will be shown quantitatively later. As with position in the product life cycle, the assumption on the initial share positions are changed within the model, holding everything else constant, according to the plan set out in Figure 4-17.

FIGURE 4-17. INITIAL MARKET SHARE

FIRM	COMPETITOR
90%	10%
80%	20%
70%	30%
60%	40%
50%	50%
40%	60%
30%	70%
20%	80%
10%	90%

Remember, the model assumes only two participants -- the firm and a competitor. If there are three or more participants then, as discussed in the section "Limit Pricing", the firm cannot set a price pattern to discourage all competitors' expansion based solely on competitive net present value. The firm must use a "carrot and stick" approach on the moderate cost competitors to discourage their expansion eventhough expansion might look profitable to those competitors based on prices set by the firm. The usefulness of this model depends on the assumption that either there is only one competitor, or if there are multiple competitors, the "carrot and stick" approach discourages their expansion as well.

The final factor effecting the firm's net present value of further investment in an SBU is the initial cost position of the firm relative to competition. In this model, the initial cost position is determined by the selection within the model of the initial position in the product life cycle and the initial share position of the participants. The model assumes further, that the initial share positions have remained constant over the period from the beginning of the product life cycle to the current position in the product life cycle. For example, using the "standard" product life cycle shown in Figure 4-12 and the 60-40% initial market share assumption from Figure 4-16, the initial cost position of the firm in year one of the product life cycle would be based on a cumulative volume of 60 (i.e. total cumulative volume of 100 units times 60% market share). Similarly, the competitor's initial cost position would be based on a cumulative volume of 40. Skipping to an assumed initial position in the product life cycle of year three, the initial cost position of the firm would be based on a cumulative volume of 360 (i.e. total cumulative volume of 100 + 200 + 300 = 600 units times 60% market share). This assumption of constant past market share simplifies computations in the model. However, if the real world demands it, any pattern of market share could be substituted with minor adjustments to the model and no loss of theoretical accuracy.

Assumptions for the calculation of incremental cash flows and net present value

There are a number of assumptions built into the model that are used to calculate incremental cash flows and net present value. Each of these assumptions will be discussed in turn. Generally, each assumption made simplifies computations and if it does not "fit" in a particular case, different assumptions could be substituted with minor adjustments and no loss of theoretical accuracy.

Costs are standardized in such a way that each participant's cost per unit will equal $10 when his accumulated volume reaches 1000 units, assuming a 75% experience curve slope. Actually, costs are set such that the first unit produced cost $175.84, independent of the experience curve slope.

Investment requirements for capital assets are assumed to be $1 for each $1 in cost of goods or services produced and can be added in any size increments. For example, if in a particular year the cost of producing 100 units is $1000 and the previous year there was no production, then the investment requirement for 100 units of capacity would be $1000. Investment requirements, expressed in dollars per unit of capacity, are assumed to fall in line with cost declines through experience. Further, capital assets, no matter when purchased, are assumed to have a useful life at least as long as the remaining product life cycle, with no salvage value.

Marginal tax rates are assumed to be 50% with all of the cost of capital assets immediately deductible (i.e. assets are expensed not capitalized and depreciated). Taxable losses in any year generate the equivalent of a tax refund based on the 50% marginal tax rate. In other words, it is assumed either the firm has a sufficiently large tax loss carryback, or that the firm's other endeavors produce sufficient taxable income to offset losses in the particular SBU. No investment tax credits are included.

It is assumed that there is no required working capital investment and therefore production matches sales in any given year, and there is no inventory. Further, all sales and all purchases of materials and labor are on a cash basis.

The cost of capital is assumed to be 15% for both the firm and the competitor. The cost holds constant over the entire product life cycle and is not influenced by the riskiness of the SBU to either firm or competition.

Inflation is assumed to be zero over the entire product life cycle. Therefore, costs decline fully with experience, as does the cost of capital assets.

Model logic

Following is a discussion of the mathematical relationships used in the model to calculate the net present value to the firm of adjustments to market share. The actual computer program, written in Fortran, is available in Appendix 5.

As previously discussed, the model begins with the "standard" assumptions about how the firm and competition view the product life cycle, what the slopes of the experience curves are for both the firm and competition, and what the initial positions are both in the product life cycle and for each participant's market share. For example, assume the product life cycle is that shown in Figure 4-12, the slope of both participants experience curve is 75%, we are at the beginning of the product life cycle and the initial share positions are 60% for the firm and 40% for the competition.

The model assumes the firm adjusts market share by discouraging competitive expansion by pricing such that the net present value to the competitor of further expansion is always zero. The major unknown in the calculation is therefore the price pattern to yield zero net present value to the competitor based on his incremental economics. The present value to the firm of such a strategy is then determined by the firm's costs and investment requirements again on an incremental basis, given the price pattern required to discourage competitive expansion. As required by capital budgeting theory, the attractiveness of investment must be determined on incremental economics -- the difference between investing and not investing. Therefore, the model proceeds along two parallel tracks. It determines the economics for both participants assuming market shares remain constant (i.e. the competitor adds capacity proportional to increasing sales) and assuming the firm preempts all market growth (i.e. the competitor adds no additional capacity).

The first step is to calculate cost as a function of time for both participants and both market share assumptions. The following equation holds:

$$C_t = \$10\ \left(\sum_{t=1}^{n} Vol_t \times Share_t \div 1000\right)^{-.41504}$$

It can be interpreted that cost in any year t equals an initial cost which declines over time with experience. As discussed, the \$10 and the division by 1000 set an initial cost such that the cost will be \$10 when cumulative volume reaches 1000 units. The summation of volume times share for any year t calculates cumulative volume, and the exponent (-.41504) assures that costs decline 25% for each doubling of experience (i.e. log .75 v log 2 = -.41504). Let's do a couple of years calculations to get the feel of it!

Industry volume for year 1 is 100 and for year 2 is 200 from Figure 4-12. Assume first that market share remains 60% for the firm and 40% for competition. If so, the firm's cost in year 1 would be:

$$C_1 = \$10(100 \times 60\% \div 1000)^{-.41504}$$

$$C_1 = \$32.14$$

In year 2, the cost would decline as industry cumulative volume expands to 300 (100 + 200) as follows:

$$C_2 = \$10(300 \times 60\% \div 1000)^{-.41504}$$

$$C_2 = \$20.37$$

For the competitor, calculations are identical, except that his 40% share is substituted for the firm's 60% share. The results are costs of $38.04 and $24.11 respectively.

Next assume the firm prices to discourage competitive expansion. The competitor is then limited to 40 units of sales per year, the same as his initial capacity. Costs remain $32.14 and $38.04 respectively in the first year, but they change in the second year because the firm cumulative volume grows to 220 (60 + 160) while the competitor's cumulative volume is only 80 (40 + 40) because his capacity is limited to 40 units per year. Second year cost can then be calculated for the firm:

$$C_2 = \$10\ (220 \div 1000)^{-.41504}$$

$$C_2 = \$18.75$$

and for the competitor:

$$C_2 = \$10\ (80 \div 1000)^{-.41504}$$

$$C_2 = \$28.52$$

Note, the firm's cost advantage grows with additional experience.

The second step is to calculate the competitor's incremental net cash flow from operations for investing. Adding the built-in assumptions already discussed, the following equation holds:

$$\text{INC NE}_t = 0.5[(P_t-C_t)\ \text{Vol}_t \times \text{share}]_{\text{with}} - 0.5[(P_t-C_t)\ \text{Vol}_t \times \text{share}]_{\text{without}}$$

It can be interpreted that the net earnings if the competitor expands less the net earnings if he does not expand yield the incremental net earnings from the expansion. Net earnings, at any time t, are the unit price, P_t, less the unit cost, C_t, multiplied by the sales volume (the product of Vol_t and share) all multiplied by one minus the marginal tax rate (assumed to be 50%). Clearly C_t will differ if the competitor expands versus not. For example, in the second year as already calculated, his cost will be \$24.11 if he expands versus \$28.52 if he doesn't. Also, sales volumes will differ. Second year volume will be 80 units if competition expands (40% of 200) versus 40 units if he doesn't (limited by capacity). Further, and very importantly, prices will also differ. In the section, "Integration of the Tools" , I elected to set a price pattern as a function of the firm's costs -- in fact a constant markup. Since the firm's costs are a function of whether or not competition expands, P_t will differ as well. Allowing the unknown (p), to be that markup on the firm's cost, the unit price (P_t) can be expressed as:

$$P_1 = p \times \$32.14 \text{ and } P_2 = p \times \$20.37$$

if the competitor expands versus

$$P_1 = p \times \$32.14 \text{ and } P_2 = p \times \$18.75$$

if the competitor fails to expand.

Therefore, substituting the above relationships, we can write the competitor's incremental net cash flows from operations (in this case simply incremental net earnings) as a function of the unknown price markup on the firm's cost as follows:

$$\text{INC NE}_1 = 0.5[(32.14p - 38.04)40] - 0.5[(32.14p-38.04)40]$$
$$\text{INC NE}_2 = 0.5[(20.37p - 24.11)80] - 0.5[(18.75p-28.52)40]$$

The third step is to calculate the incremental investment cash flow to the competitor. Using the built in assumptions, the following equation holds:

$$F\text{-}INV_t = 0.5[(Vol_{t\text{-with}} - Vol_{t\text{-without}})C_{t\text{-with}}$$

It can be interpreted that the investment requirement is the product of the increased volume sold by the competitor times a unit cost of capacity, tax effect considered. As discussed, I have assumed the unit cost of capacity equals the unit cost of production, C_t, that all capital investments are immediately deductible from taxable income, and that there is no working capital requirement. With those assumptions we can write the competitor's incremental net cash flows from investment as follows:

$$F - INV_1 = 0.5[40 - 40] \times 38.04$$
$$F - INV_2 = 0.5[80 - 40] \times 24.11$$

Since the incremental net cash flow from investment is always a cash outflow due to the assumptions of zero salvage value and no working capital recovery, we can now write the competitor's full incremental net cash flow as follows:

$$F_t = INC\ NE_t - (F - INV_t)$$

with INC NE_t being a function of the yet unknown price markup on the firm's costs. However, we have a mathematical way to calculate that price markup! The competitor will not expand if his net present value does not exceed zero. That relationship can be written as:

$$NPV = 0 = \sum_{t=\text{initial year}}^{20} F_t \div (1 + k)^{t-\text{initial year} + 1}$$

where F_t is the competitor's full incremental net cash flow, which is discounted at his cost of capital (assumed to be 15%). Net present value equals zero because the price pattern included in the cash flows is precisely that which makes net present value zero. Therefore, the output of the above equation is the required price markup, p, first discussed in the calculation of the competitor's incremental net cash flow from operations.

The final step is to calculate the firm's net present value based on its incremental net cash flows, now knowing the required price mark-up to assume competition does not expand. The equations are identical, in theory, to those discussed for the calculation of the competitor's incremental net cash flows and net present value. For the sake of brevity, they will not be repeated here. On to the results!

CHAPTER 5

MAPPING RESULTS

Recall, the model described in the preceding chapter calculates the incremental NPV to the firm of a strategy of pricing to discourage competitive expansion as a function of (1) how the firm views the current position in the product life cycle, (2) the firm's current market share, (3) the competitor's view of the shape and size of the product life cycle, and (4) how successful the firm is compared to the competitor in reducing costs through experience. The calculation is based on the incremental economics of both the firm and a competitor in an assumed two participant market.

The relationship theorized can be simply expressed mathematically as:

$$NPV = f\ (N,\ S_A,\ E_B,\ R\ )$$

where N is the position (year) in the product life cycle as viewed by the firm, S_A is the firm's initial market share in year N, the year the firm's strategy of increasing share begins, E_B is the slope of the competitor's experience curve slope, assuming the firm's experience curve slope is held constant, and R, the competitor's required rate of return, is the surrogate for how the competitor views the product life cycle.

It is the goal of this chapter, the heart of this thesis, to:

* Show graphically how NPV changes as the variables change.

* Determine the importance of each variable in its influence on NPV.

* Define quantitatively the pricing implications of the firm's strategy to discourage further investment by competition in the SBU

FACTORS AFFECTING NET PRESENT VALUE

This thesis assumes that NPV is a function of 4 variables: N, S_A, E_B and R. As described previously, the computerized model changes the variables, one at a time holding the others constant and calculates NPV. Since each variable changes many times: N(19), S_A(9), E_B(5) and R(7), the number of NPVs calculated is large (5985). Therefore, I will be selective in the results I present. Within this section, results will be shown in two ways. First, NPV versus one variable graphs, all other variables held constant. Second, two separate variables will be graphed (one horizontally, the other vertically) with isobars of NPV mapped out, holding the other variables constant. The second method is, I think, particularly useful since it follows the form of the portfolio matrices proposed by the Boston Consulting Group, McKinsey and others. Appendix 3 shows in tabular form all the numbers used to prepare the graphs presented in this section. The tables themselves are taken directly from the computer output, which exceeds 75 pages and is not attached to reduce bulk.

The first presentation format shows NPV on the y-axis as a function of one variable on the x-axis, two other variables held constant, and selected values of the fourth variable shown to reduce the number of graphs and to aid comprehension. Considering that there are four variables, there will be four basic types of graphs:

1. NPV vs Position in the Product Life Cycle, as viewed by the Firm

2. NPV vs The Firm's Initial Market Share Position

3. NPV vs The Competitor's Experience Curve Slope

4. NPV vs The Competitor's View of Its Product Life Cycle

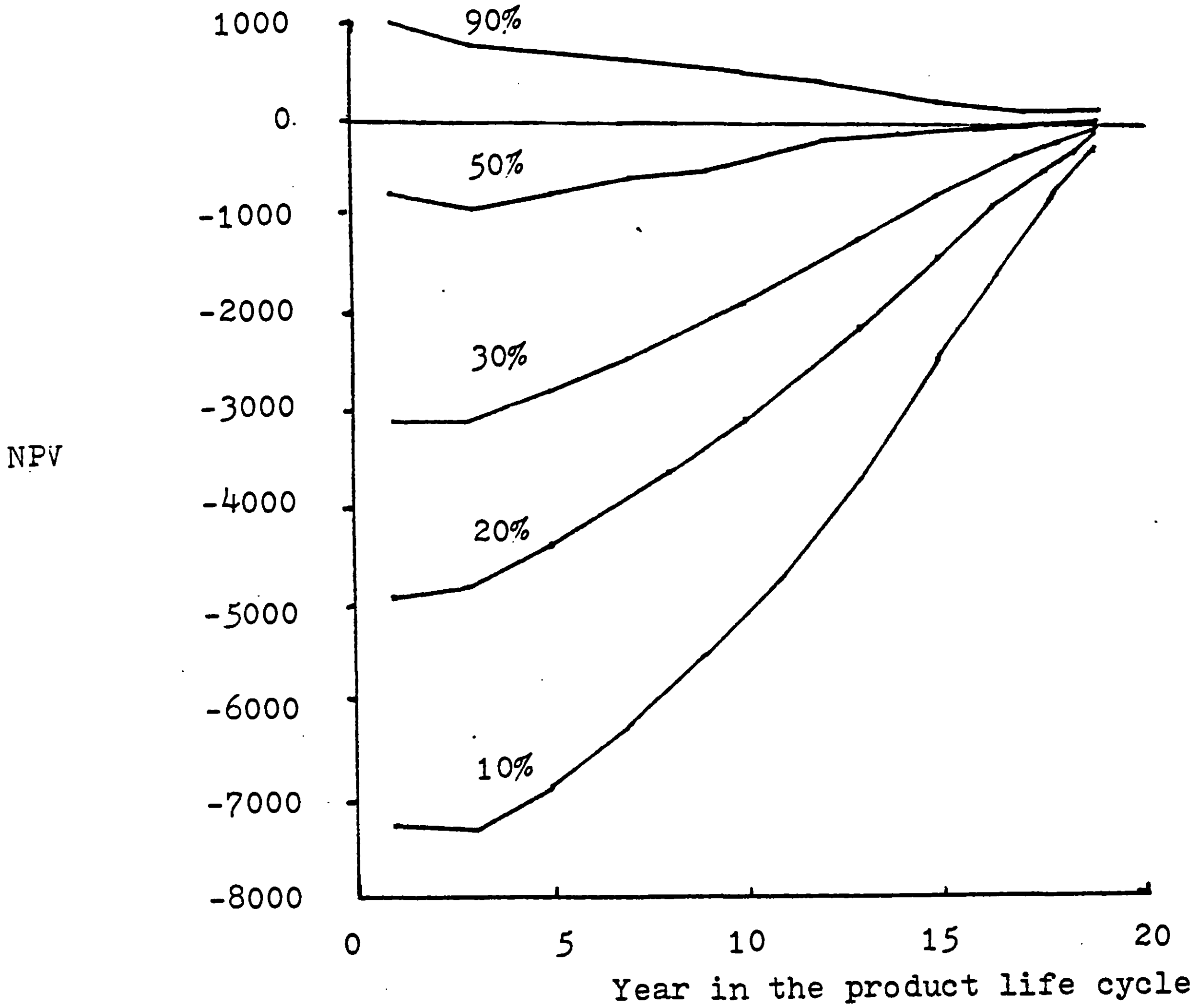
Since I am presenting selected rather than comprehensive data, each basic type of graph will have at most a few, but certainly not all, variations, based on changes in the other three variables.

<u>Net present value versus position in the product life cycle, as viewed by the firm</u>

Figure 5-1, on the next page, shows NPV as a function of position in the product life cycle for selected initial market share positions, assuming both the firm and the competitor have equal experience curve slopes, i.e., $E_B = .75$, and both see the product life cycle exactly the same, i.e., R = .15.

As expected, NPV approaches zero as the product matures, independent of NPV earlier in the product life

FIGURE 5-1. NPV = f (PRODUCT LIFE CYCLE) AT VARIOUS S_A, E_B=.75, R=.15



cycle. Including selected initial market share positions for the firm shows that if the investment in additional market share is a "good" investment, e.g., at S_A = 90%, then NPV declines as a function of time. And, if investment in market share is a "bad" investment, e.g., at S_A = 10%, then NPV rises as a function of time and becomes less "bad".

The relationship between NPV and position in the product life cycle is not controversial. Logic demands that NPV be inversely related to the remaining product life if NPV is positive. Conversely, if NPV is negative it should rise as the product matures, i.e., as N increases. Perhaps the more interesting aspect of Figure 5-1 is the implied relationship between NPV and the firm's initial share position, S_A. Under the conditions of Figure 5-1, NPV is strongly negative at low initial share positions and only slightly positive at high initial share positions . This is the subject of the next sub-section.

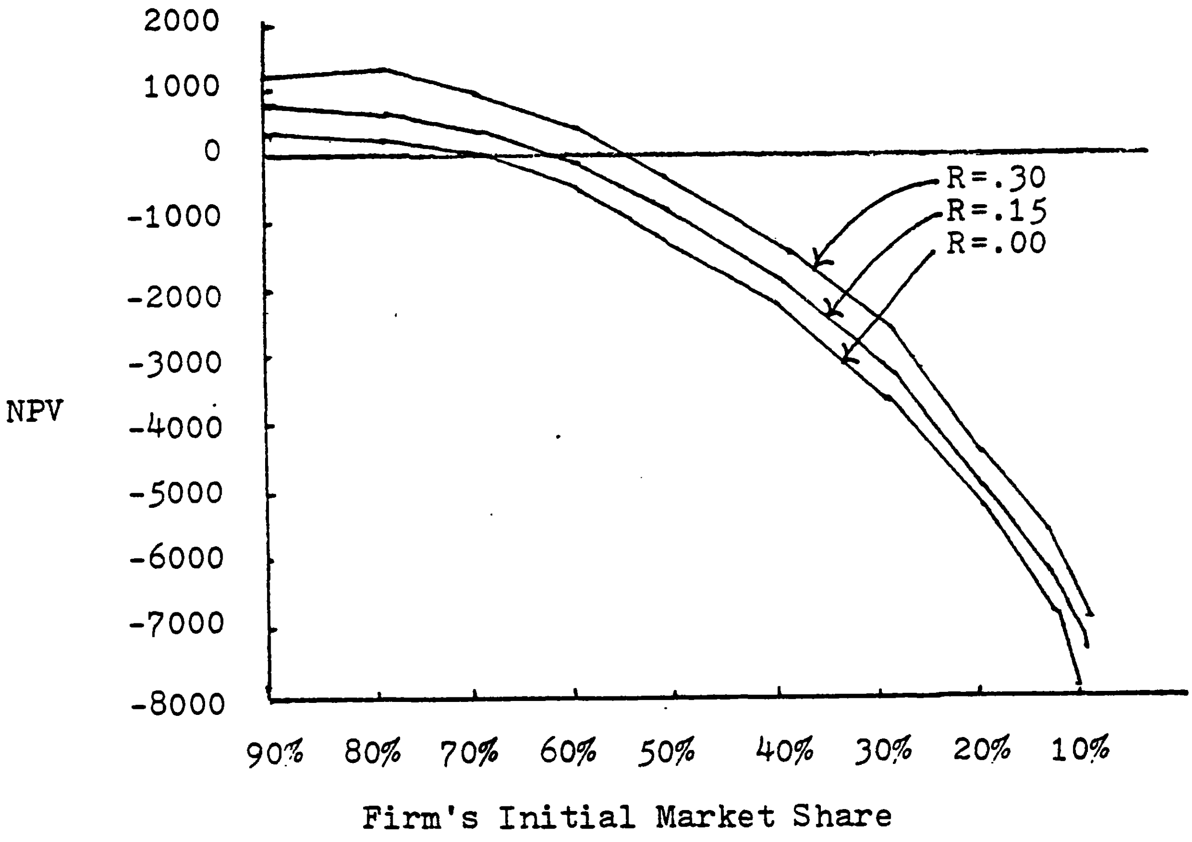
Net present value versus the firm's initial share position

Figure 5-2, on the next page, shows NPV as a function of initial share position at selected competitive views of the product life cycle, assuming both the firm and the competitor have identical experience curve slopes, i.e., E_B = .75 and the product is "new", i.e., N = 1.

Logic from microeconomics suggests, everything else equal, that NPV declines as the firm's market share decreases. The reason is simple. High market share is a surrogate for a high degree of monopoly power. Since monopoly power allows for supranormal profits, it makes sense that investments to protect those high profits would be attractive.

As expected, NPV falls as share declines. In fact, the rate of decline accelerates as the firm's initial share diminishes. Note also that NPV falls below zero for all initial market share positions below the 50%-70% range.

FIGURE 5-2 NPV = f(FIRM'S INITIAL SHARE) AT VARIOUS R, E_B = .75, N = 1

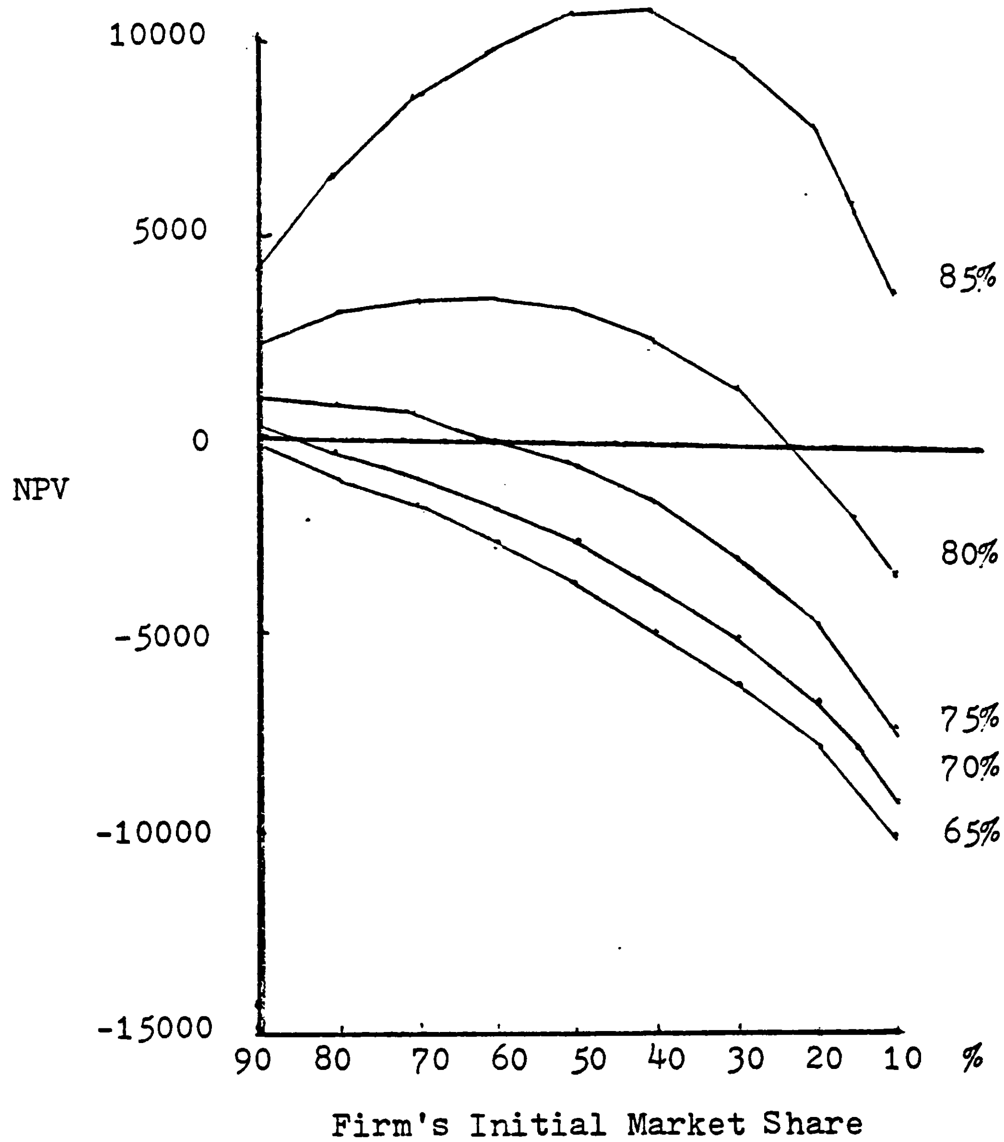


It appears that there is a threshold level or "critical mass" of market share that must be attained before price warfare to dominate a business becomes attractive, at least when competitors have equal competence, as measured by their experience curve slope. Perhaps the most important conclusion from Figure 5-2 is that if the firm's initial market share is below this "critical mass", the firm can not attractively increase its market share through price warfare. The graph shows the NPV of such a strategy consistently negative.

Figure 5-2 allows for the effect of different views of the product life cycle by the competitor to be considered. Recall, the competitor's required rate of return, the variable R, is the surrogate for different competitive views of the size and shape of the product life cycle. A large R, say R = .30, means that it appears to the firm that the competitor requires an IRR of 30% to invest. Since both participants are assumed to have equal cost of capital, the competitor must view the market as less attractive (i.e., a smaller product life cycle) than does the firm. Conversely, a low R, say R = 0, means the competitor sees the market as more attractive than does the firm. As would be expected, Figure 5-2 shows the firm's NPV higher at all initial share levels as the competitor's view of the market's attractiveness declines (that is as R increases).

Figure 5-3, on the next page, again shows NPV as a function of initial share position, this time at selected experience curve slopes for the competitor, assuming both the firm and the competitor see the product life cycle exactly the same, that is R = .15, and the product is "new", that is N = 1. As would be expected, the firm's NPV is higher at all levels of initial market share if the firm has an experience curve slope advantage over the competitor. However, contrary to Figure 5-2, the firm's NPV does not fall, in all cases, as share declines. In fact, when the firm has a large experience curve slope advantage, NPV grows as share declines to about the 40% share level.

FIGURE 5-3 NPV = f (FIRM'S INITIAL SHARE) AT VARIOUS E_B, R = .15, N = 1



The cause of such an apparent anomaly is a built-in assumption of the model -- the assumption that the price elasticity of demand is zero. That is, the same quantity will be demanded at any price. Appendix 4 includes a detailed explanation of this elasticity assumption's effect on the firm's NPV. I have elected to reserve that detailed discussion to the appendix to preserve continuity within this chapter. However, I do believe a discussion of the reasonableness of the elasticity assumption used in this thesis is appropriate here, even though it requires a slight diversion in the trend of thought.

The price elasticity of demand measures the percentage change in quantity demanded for a given percentage change in price. Elasticities vary widely among products and services and vary whether we are referring to the short run or long run. Further, elasticities are not constant over large variations in price and can generally be expected to vary as a function of price, since they are nothing more than a weighted first derivative of the demand curve function. Obviously, all products and services have a negative (due to the downward sloping demand) and non-zero elasticity, except perhaps for air for the purpose of breathing.

This model requires that some assumption be made about the price elasticity of demand. Figure 3-3, in the section entitled, "The Product Life Cycle" demonstrates the theoretical effect of elasticity on industry sales volume as a function of price strategy. However, in building the model I am forced to be specific about exactly how the "standard" product life cycle used will be affected by price changes. I have elected to assume zero elasticity! Is that assumption realistic and useful for business research? The answer is "sometimes" to the first part of the question and "probably yes" to the second part.

Many products and services do have a very low elasticity, e.g., cigarettes and electricity. Thompson (1981:138-140) lists characteristics of products that would tend to have low elasticities as:

* An important product to the buyer.
* A product near market saturation.
* A low price relative to income levels.
* A product with few if any close substitutes.
* A product with a very limited use.
* A non-durable product.

Is an assumption of zero elasticity generally useful? Obviously, the closer any product is to zero elasticity the more representative the results of this thesis. Alternately, a variable price elasticity of demand could easily be built into the model, but the practical job of specifying the elasticity function for a particular product would be very hard, and is not attempted here.

Is an assumption of zero elasticity useful for business research? I believe it is as good as any, if we recognize the assumption and are wary of stating conclusions claimed to be generally applicable. Since elasticity can vary greatly among products, over time and products, over time and over price ranges, any elasticity function used in this general model would have to be totally arbitrary. The advantage of using zero elasticity over any other is that it simplifies the model.

Net present value versus the competitor's experience curve slope

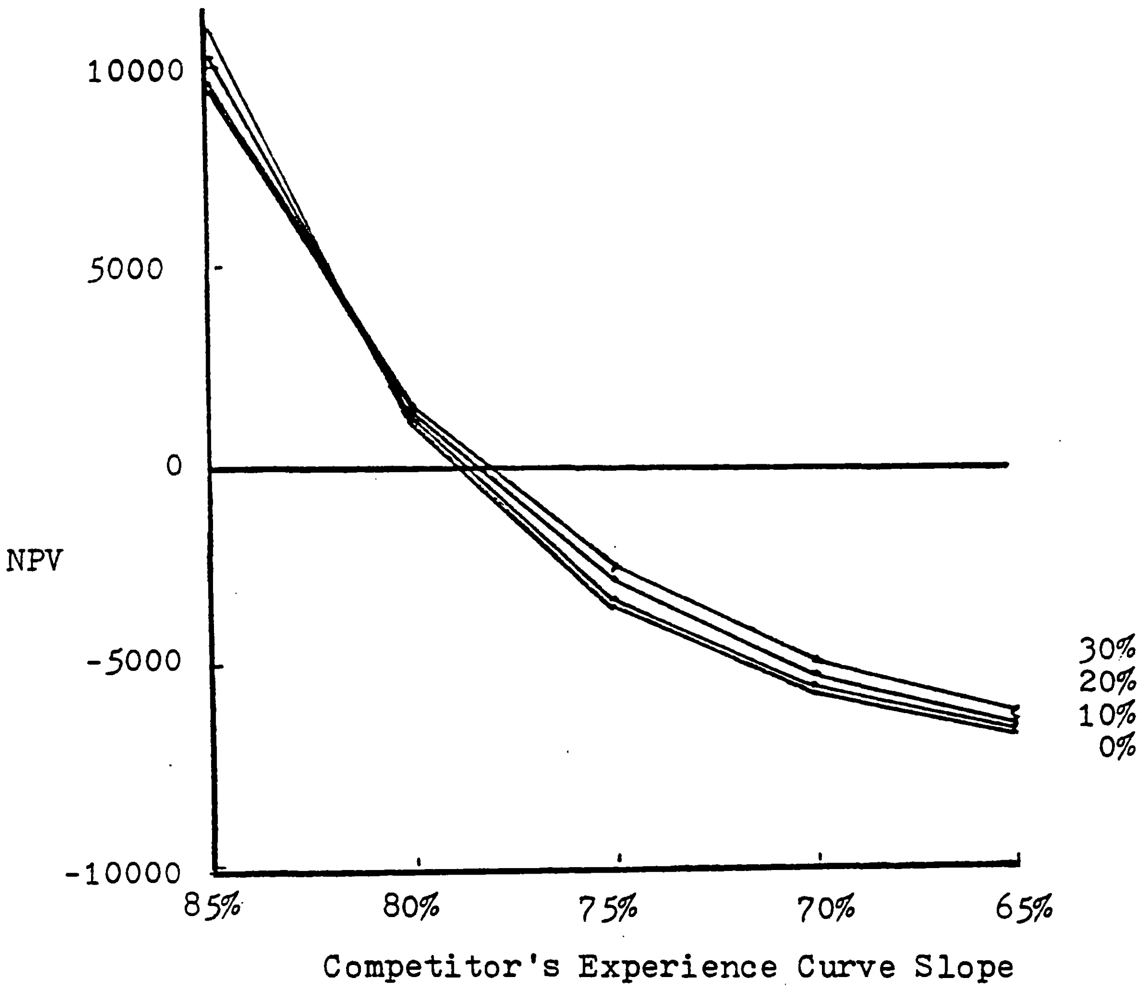
Figure 5-4, on the next page, shows NPV as a function of the competitor's experience curve slope for selected competitive views of the product life cycle, assuming the product is "new", i.e., N = 1, and the firm has a small initial market share, i.e., S_A = 30%.

The results show NPV declining as the firm's experience curve slope advantage decreases, as expected intuitively and as shown in Figure 5-3. Also as expected, NPV is highest when the competitor views the market as less attractive than does the firm, i.e., R is large.

Net present value versus the competitor's view of the product life cycle

Figure 5-5, on the second following page, shows NPV as a function of the competitor's view of the product life cycle, as measured by the surrogate required rate of return, at selected initial market share positions for the firm assuming the product is "new", i.e., N = 1 and

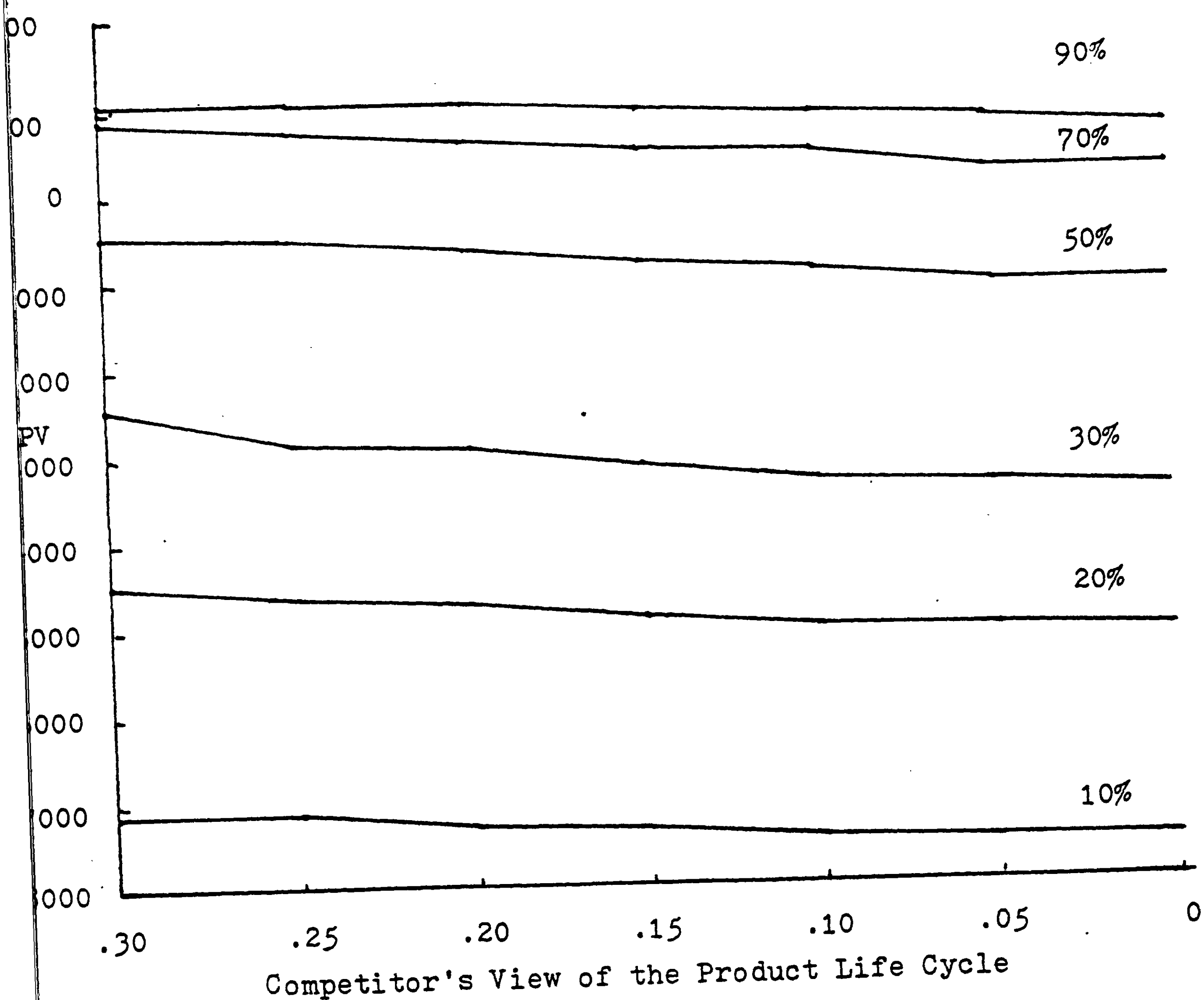
FIGURE 5-4. NPV = f (COMPETITOR'S EXPERIENCE CURVE SLOPE) AT VARIOUS R, S_A = 70%, N = 1



assuming the competitor and the firm have equal experience curve slopes.

The results are noncontroversial. The firm's NPV is greater when the competitor views the product as less attractive than does the firm and the firm's NPV is strongly dependent on its initial share position -- both as expected. It is interesting however, that the relationship between NPV and the competitor's view of the market is essentially linear, independent of share.

FIGURE 5-5. NPV = f(COMPETITOR'S VIEW OF THE PRODUCT LIFE CYCLE) AT VARIOUS S_A, N = 1, E_D = 65%



The second way I have elected to show results is with two variable graphs showing isobars of constant net present value. I consider this an important presentation of data since it follows the format of the matrix analyses proposed by both the Boston Consulting Group and McKinsey and Company. However, before beginning, let me compare and contrast thesis assumptions with both BCG's and McKinsey's work.

The Boston Consulting Group matrix shows the cash flow implication of SBUs as a function of relative market share and market growth. BCG divides the matrix into four quadrants -- question marks (or problem children), stars, cash cows and dogs. The division along the relative market share axis generally is shown to occur at a value of 1.0, which corresponds to a value of S_A = 50%, in my assumed two participant market. That is, if S_A = 50%, then S_B = 50% and S_A v S_B = 1.0. The division along the market growth axes generally is shown to occur at a market growth rate of 10% per year. This corresponds to year 11 in the position in the "standard" product life cycle. That is, in year 11 sales are 1100, 10% more than the 1000 level of sales in year 10. Therefore, the BCG matrix is easy to translate into the format used in this thesis.

This thesis calculates the net present value to the firm of a pricing strategy to discourage a competitor from further investment in an SBU. In effect, the net present value of incremental cash flows to the firm of a leftward move within BCG's Growth-Share matrix. BCG, however, uses the Growth-Share Matrix more as a tool for balancing cash flows within the firm. They contend that the excess cash that results from normal operation of cash cows and the divestment of dogs should be reinvested in stars and the remainder invested in selected question mark SBU's, to balance cash flows within the firm. In that sense, BCG does use the Growth-Share Matrix as a guide for investment attractiveness -- stars and at least certain question mark SBU's are attractive for further investment (with the relative attractiveness of investments not specifically mentioned); and cash cows and dogs are unattractive.

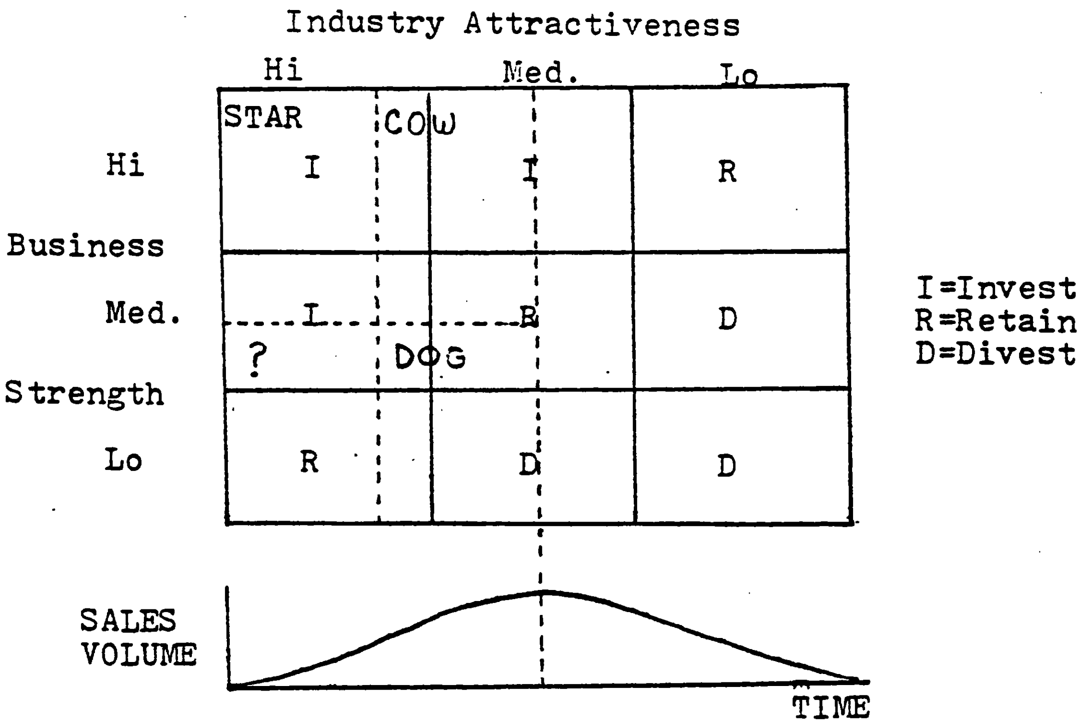
McKinsey's Industry Attractiveness-Business Strength matrix, while not nearly as quantitative in defining its axes, seems to be quite specific in its investment recommendations. As you will recall, the McKinsey matrix is divided into nine blocks by splitting both industry attractiveness and business strength into above average, average and below average categories. The three blocks which contain at least one above average classification have the directive: "invest". The three blocks which contain at least one below average classification have the directive: "divest". The rest we are supposed to "retain". Can we assume that "retain" means to invest enough to maintain the firm's current position in that SBU, i.e., grow with the market? If so, then the "invest" directive must mean to concentrate resources to grow faster than the market, i.e., gain market share. Reminded again that this thesis calculates the firm's net present value of a price strategy of increasing market share, it appears that the McKinsey matrix implies that such net present value is positive when the directive is "invest", negative when the directive is "divest", and about zero when the directive is "retain".

Finally, let me try to categorize the McKinsey matrix using only two of the four variables used in this thesis. My choice for industry attractiveness must be N, the position in the product life cycle, the same variable used for the market growth axis in BCG's matrix. McKinsey themselves relate industry attractiveness to the product life cycle in their own presentations of their matrix. My choice for the business strength axis is E_B, the competitor's experience curve slope. Eventhough McKinsey lists many ideas such as technological competence, financial and human resources, product strength and image in determining business strength, the common thread seems to me to be adequately encompassed by the idea of competence, eventually to be measured by the firm's ability to reduce costs quicker than its competitor.

Interestingly few, if any, have noticed a significant difference between the BCG and McKinsey matrices. BCG themselves show the dividing line between "Stars" and "Cash Cows" at 10% growth per annum and never display negative growth rates. See for example Hedley

(1977:12). Therefore, in terms of the product life cycle, BCG's matrix ends at the point of peak sales volume and does not consider declining sales. McKinsey on the other hand, relates their matrix to the full product life cycle including declining sales. See for example my Figure 2-5 "The McKinsey Matrix". Therefore, as presented, the BCG matrix is but the left-hand side of the McKinsey matrix. Figure 5-6 superimposes BCG's matrix on McKinsey's.

FIGURE 5-6 THE BCG MATRIX SUPERIMPOSED ON THE MCKINSEY MATRIX



diverge on certain of their investment recommendations. For example, according to BCG, only certain queries should be selected by the firm for further support with the rest divested early on. However, if BCG's matrix can be superimposed on McKinsey's, as drawn, then McKinsey's advice for these SBUs is that the majority, at least as measured by area, should be retained with the remainder invested in, not divested.

The following subsections show six forms of the proposed two variable graphs showing isobars of constant net present value. Six are required since this thesis assumes that:

$$NPV = f(N, S_A, E_B, R)$$

Given four variables -- one each on the x- and y-axes and two held constant -- yields six combinations. They are:

N, S_A	S_A, E_B
N, E_B	S_A, R
N, R	E_B, R

The first (N, S_A) is the equivalent of the Boston Consulting Group's Growth-Share matrix. The second (N, E_B) is my approximation to the McKinsey matrix. The other four are more esoteric, but I hope no less interesting. Ideally, I would map out NPV in four dimensional space to show graphically the full relationships. Alas, paper only permits two dimensions at a time. However, multiple regression, the subject of the next section will allow us to study the importance of each variable in net present value.

Position in the product life cycle versus the firm's

<u>initial market share (N, S_A)</u>

Figure 5-7, on the next page, shows isobars of constant net present value as a function of position in the product life cycle and the firm's initial market share, assuming both competitor's have equal experience curve slopes, i.e. E_B = .75, and the competitor views the market as much less attractive, i.e., R = .30.

As expected from previous work, the firm's NPV increases as its initial share position increases and as the years remaining in the product life cycle increase. That is, the "payoff" from a policy of pricing to preempt all future market growth is high when relative market share is high and when growth is high. Using BCG's terms, that means "stars" are most attractive for further investment. However BCG also implies that certain "problem children" are also attractive as in investment, with the idea of developing them into future "stars". My work, however, indicates that "problem children" are incorrigible! That is, they can not be profitably converted into "stars" if the firm must buy market share with price, at least if the participants are equally competent and view the market the same.

BCG sees "cash cows" as unattractive investments primarily because slow growth businesses do not require much investment to maintain share, but also they suggest attempts to increase share will be unattractive. My work,

FIGURE 5-7. NPV = $f(N, S_A)$, E_B = .75, R = .30

STAR "?"

N	90	80	70	60	50	40	30	20	10
1	1179	1216	937	418	-329	-1334	-2660	-4448	-7068
2	1055	1068	785	273	-465	-1460	-2782	-4579	-7227
3	968	975	706	220	-485	-1443	-2729	-4500	-7150
4	895	902	652	196	-468	-1380	-2616	-4339	-6963
5	829	837	607	183	-439	-1298	-2476	-4138	-6714
6	767	777	566	175	-403	-1209	-2323	-3915	-6425
7	707	720	528	168	-366	-1117	-2163	-3676	-6103
8	648	663	490	162	-328	-1021	-1997	-3423	-5753
9	591	606	452	156	-290	-925	-1825	-3159	-5375
10	533	549	413	149	-252	-827	-1649	-2881	-4969
11	475	492	373	141	-214	-727	-1468	-2591	-4534
12	418	435	333	132	-177	-627	-1282	-2288	-4067
13	359	376	292	122	-141	-526	-1092	-1974	-3570
14	301	317	249	110	-107	-427	-902	-1651	-3042
15	244	258	206	96	-75	-331	-713	-1324	-2491
16	187	200	162	80	-48	-240	-530	-1000	-1924
17	132	143	118	62	-25	-158	-359	-691	-1360
18	81	89	74	42	-9	-88	-208	-409	-825
19	36	40	34	21	0	-34	-86	-172	-356

COW DOG

on the other hand, indicates that further investment in these slow growth, high share SBU's is attractive, even to the point of attempting to preempt all remaining market growth with price. Taken as a group, "cash cows" are the second most attractive for further investment. "Dogs", as predicted by BCG, are unattractive.

Note, however, that the isobars of NPV make it clear that BCG's categories are not homogeneous, at least based on the "dividing lines" suggested by BCG . Some "dogs" have higher NPV than some "stars". Compare, for example the NPVs for Point A versus Point B on Figure 5-7. As a general rule though, share is much more important in determining NPV than is growth.

Figure 5-8, on the next page, has the same conditions as Figure 5-7 except that the competitor sees the market exactly the same as does the firm, i.e. R=.15. Again, I have superimposed BCG's boundaries on the data.

I am presenting Figure 5-8 not because the conclusions of Figure 5-7 become invalid if the competitor's view of the market increases. The same conclusions hold. However, the logical dividing line on the market share axis does move. Recall, the Growth-Share matrix shows market share high above 50% (for my model), and Figure 5-7 displayed a shift between negative and positive NPV's near there. Figure 5-8 shows a similar shift, but in this case it occurs above 60% early in the product life cycle. Interestingly, this is exactly the results described by the BCG (Hedley (1977)) themselves.

FIGURE 5-8. NPV = $f(N, S_A)$, E_B= .75, R= .15

STAR "?"

N	90	80	70	60	50	40	30	20	10
1	947	884	538	-23	-795	-1801	-3105	-4840	-7360
2	845	767	424	-125	-882	-1874	-3168	-4904	-7443
3	776	700	374	-148	-871	-1827	-3087	-4798	-7336
4	720	649	346	-145	-829	-1741	-2954	-4621	-7137
5	670	607	327	-171	-773	-1636	-2796	-4408	-6883
6	624	529	312	-112	-712	-1524	-2624	-4173	-6589
7	579	533	298	-91	-647	-1406	-2443	-3920	-6263
8	536	497	285	-70	-582	-1284	-2254	-3652	-5908
9	492	461	272	-60	-512	-1160	-2059	-3370	-5523
10	448	424	257	-40	-449	-1035	-1857	-3073	-5108
11	403	385	240	-12	-384	-907	-1650	-2761	-4661
12	357	345	222	3	-320	-780	-1438	-2436	-4181
13	310	303	200	16	-259	-653	-1223	-2099	-3669
14	262	259	177	25	-201	-529	-1007	-1754	-3126
15	214	214	150	31	-148	-409	-794	-1405	-2558
16	165	167	121	33	-101	-298	-590	-1061	-1976
17	118	121	90	30	-62	-197	-401	-732	-1397
18	72	75	58	23	-31	-112	-234	-434	-848
19	32	34	27	12	-10	-45	-97	-184	-367

COW DOG

They show the dividing line between "Stars" and "?" at 1.5 relative market share (60% in my model) shifting to 1.0 relative market share as the dividing line between "Cash Cows" and "Dogs".

More importantly, perhaps, both Figures show there is no logical dividing line on the growth axis (the equivalent of N in model). "Stars" blend gradually into "cash cows" and "question marks" blend gradually into "dogs", contrary to the suggestions of BCG.

My criticism of the Boston Consulting Group's Growth-Share matrix is not with the cash flow implications of each quadrant. Adding the experience curve and managing the SBU for dominance using limit pricing do not cause conflict. However, I do disagree with their investment implications. My results indicate it is unattractive to invest in market share expansion if initial market share is low to begin with, if share must be bought with low price. Therefore "Problem Children" and "Dogs" do not merit further investment, unless share is effectively given to the firm free by a competitor's mistake. Also, "Cash Cows" deserve further investment so they may expand share, even though market growth is slow.

What is it in the model or its assumptions that causes investment recommendations to differ between this thesis and the Boston Consulting Group? Without the aid of a psychic I can only speculate, but I must conclude that BCG under estimated the importance of their own experience curve. By splitting their matrix into four quadrants they imply a symmetry of importance between share and growth. Including the quantitative effect of the experience curve magnifies the importance of share over growth. The rule now becomes -- look for SBUs where the firm has a large current market share, then favor those SBUs with the faster market growth. The BCG's four block matrix collapses to two blocks for investment decisions, though not for cash flow balancing, at least down to the point where sales begin to decline.

With these rules, where do the firm's new products come from as its former "Stars" mature to "Cash Cows" and eventually disappear? The answer can only be that they must be developed by the firm through its own research, or much less likely, they must be high market share businesses acquired from the outside at a price less than the present value of the firm's expected cash flows. Sticking with a low share SBU, or acquiring one, and trying to build a "Star" through price will not pay off.

Perhaps also, some of the divergence between this thesis and the common interpretation of BCG may be one of definition. Allow an example from my own industrial experience to clarify. Assume a firm invents a new plastic with unique combined properties of strength, heat tolerance, and abrasion resistance. Assume also that the plastic will find its highest value-in-use as a material for engine components in automobiles and aircraft. Engine component parts are currently made from machined steel, die-cast aluminum, die-cast zinc, and a variety of engineering plastics such as acetal, nylon, polyester, etc. What would be the definition of the market and the competition used to calculate market growth and market share? Possibilities for the definition of the market include: (1) all uses of steel, aluminum, zinc and engineering plastics, (2) uses of the same materials only in automobile and aircraft engine components, (3) only engineering plastics used in those same applications, and (4) only the firm's newly discovered plastic used in any application. The table below sets out likely initial market share, long run potential market share, and market growth rate for the firm's new plastic for each mentioned possibility.

	Market Share		Market
	Initial	Long Run	Growth Rate
Possibility 1	About 0%	About 0%	Very Low
Possibility 2	Very Low	Moderate	Low
Possibility 3	Low	High	Moderate
Possibility 4	100%	Very High	Very High

Well, what have we here -- a "Dog", a "?", or a "Star"? It all depends on the definition of the market doesn't it? An imprecise user of BCG would likely classify it a "Problem Child". I define it as a "Star"! BCG itself, as described by Hedley (1977) does follow the same definition as used here. With regard to the market, their statement that the ability to generate operating cash increases with market share because of the experience curve effect implies the firm and its competitors are providing the same product. Otherwise talk of a cost advantage based on the experience curve is meaningless.

Position in the product life cycle vs the competitor's relative experience curve slope (N, E_B)

Figure 5-9, on the next page, shows isobars of constant net present value as a function of position in the product life cycle and the competitor's relative experience curve slope, assuming both participants view the market identically, i.e., R = .15, and the firm has a 60% market share.

As expected, the NPV rises as the firm's experience curve slope advantage increases. As described in Figure 5-1, NPV declines as the time remaining in the product life cycle decreases if the investment in increased share has positive NPV and rises if it has negative NPV.

Since I proposed this combination best fits McKinsey's matrix, I have superimposed one-half of the McKinsey matrix on Figure 5-9. Recall, my work limits the product life cycle such that sales never decline, to test BCG's more quantitative matrix. As shown in Figure 5-6, that limits my conclusions regarding McKinsey's investment recommendations.

My work basically agrees with McKinsey's

FIGURE 5-9. NPV = (N, E_B), R=.15, S_A= 60%

COMPETITIOR'S EXPERIENCE CURVE SLOPE

1 2 3

N	85%	80%	75%	70%	65%
			BUSINESS STRENGTH		
1	9914	3478	-23	-1868	-2806
2	9645	3260	-125	-1857	-2707
3	9394	3117	-148	-1782	-2565
4	9115	2992	-145	-1688	-2413
5	8800	2870	-131	-1586	-2258
6	8447	2742	-112	-1480	-2103
7	8052	2608	-91	-1372	-1948
8	7616	2463	-70	-1261	-1792
9	7136	2307	-50	-1149	-1635
10	6611	2139	-30	-1035	-1476
11	6042	1958	-12	-919	-1314
12	5428	1763	3	-802	-1151
13	4773	1555	16	-685	-987
14	4079	1334	25	-567	-822
15	3357	1102	31	-452	-659
16	2617	863	33	-341	-500
17	1878	623	30	-236	-349
18	1169	390	23	-141	-211
19	525	176	12	-61	-92

4 5 6

MARKET ATTRACTIVENESS

conclusions regarding "invest", "retain",and "divest" for the cells numbered 1, 4, 5, and 6. We disagree on the other cells.

Therefore, the McKinsey matrix shown in Figure 5-10, should be redefined as shown in Figure 5-11, both on the next page; if we can accept my quantitative definition of their qualitative axes, and if we regard the NPVs in blocks 2 and 5 as essentially zero.

What is it in the model or its assumptions that causes investment decision results to differ between this thesis and McKinsey? One possibility is that they would disagree totally with my definition of their axes. The other possibility, which is more interesting, is that McKinsey either failed to include or underestimated the importance of the experience curve. McKinsey, by their matrix construction, implies a symmetry between business strength and industry attractiveness. That is, one "unit" of business strength trades off evenly for one "unit" of industry attractiveness. The experience curve upsets that relationship, if it ever existed, and magnifies the importance of business strength. The rule now becomes -- look for SBUs in which the firm is strong and favor those which are in the most attractive industries.

Position in the product life cycle vs the competitor's view of the product life cycle (N, R)

Figure 5-12, on the second following page, shows

FIGURE 5-10. THE BUSINESS STRENGTH-INDUSTRY ATTRACTIVENESS MATRIX

BUSINESS STRENGTH

INDUSTRY ATTRACTIVENESS	HIGH	MEDIUM	LOW
HIGH	INVEST	INVEST	RETAIN
MEDIUM	INVEST	RETAIN	DIVEST
LOW	RETAIN	DIVEST	DIVEST

FIGURE 5-11. THE BUSINESS STRENGTH-INDUSTRY ATTRACTIVENESS MATRIX (ADJUSTED)

BUSINESS STRENGTH

INDUSTRY ATTRACTIVENESS	HIGH	MEDIUM	LOW
HIGH	INVEST	RETAIN	DIVEST
MEDIUM	INVEST ?	RETAIN ?	DIVEST ?
LOW	?	?	?

FIGURE 5-12. NPV = f (N, R), S_A = .70, E_B = .75

COMPETITOR'S VIEW OF THE PRODUCT LIFE CYCLE

N	.00	.05	.10	.15	.20	.25	.30
1	230	318	420	538	665	799	937
2	151	227	319	424	539	660	785
3	123	198	278	374	479	591	706
4	113	180	259	346	642	545	652
5	112	174	246	327	415	509	607
6	115	172	238	312	392	477	566
7	120	172	232	298	370	447	528
8	124	172	226	285	349	418	490
9	128	171	219	272	328	388	452
10	131	169	211	257	306	358	413
11	131	164	201	240	282	327	373
12	128	157	188	222	257	294	333
13	122	147	173	200	229	260	292
14	113	133	154	177	200	224	249
15	100	118	133	150	168	187	206
16	83	95	108	121	134	148	162
17	63	72	81	90	99	108	118
18	41	47	52	58	63	69	74
19	19	22	24	27	29	32	34

isobars of constant net present value as a function of the position in the product life cycle and the competitor's view of the size of the market, assuming both participants have equal experience curve slopes, and the firm has a 70% initial market share.

As expected from previous work, NPV increases as the competitor's view of size of the the market decreases and NPV declines as the time remaining in the product's life decreases. The isobars point out that early in the product life cycle NPV is strongly influenced by how the competitor views the market, while late in the product life cycle NPV is much more strongly influenced by the passage of time.

Since no comparable matrix system has been proposed previously, I am unable to contrast my findings with other predictions. However, let me take this opportunity to comment on the implications of this matrix. Its usefulness, I believe, is primarily in directing competitive research within the firm. Clearly, the results show that the benefits of knowing how competition views the market are greatest early in the product's life cycle. Therefore, in a world of limited resources, including limited funds available for competitive research, such funds should be concentrated in SBUs early in their product life cycle.

<u>The firm's initial market share vs the competitor's experience curve slope (S_A, E_B)</u>

Figure 5-13, shows isobars of constant net present value as a function of the firm's initial market share and the competitor's experience curve slope, assuming both participants view the market identically, i.e., R = .15, and it is early in the product life cycle, i.e., N = 1.

FIGURE 5-13. NPV = $f(S_A, E_B)$, N = 1, R = .15

COMPETITOR'S EXPERIENCE CURVE SLOPE

S_A	85%	80%	75%	70%	65%
.9	4366	2248	947	166	-289
.8	6876	3079	884	-350	-1023
.7	8680	3454	538	-1040	-1866
.6	9914	3478	-23	-1868	-2806
.5	10592	3162	-795	-2837	-3852
.4	10611	2471	-1801	-3968	-5027
.3	9829	1307	-3105	-5311	-6371
.2	7863	-529	-4840	-6963	-7969
.1	3712	-3637	-7360	-9177	-10029

As expected, NPV increases as the firm's experience curve slope advantage grows. Further, there is a very strong functional relationship. Generally we would also expect the firm's NPV to decline as its initial market share diminishes. Figure 5-13 shows this to be true except for high initial share positions when the firm has an experience curve slope advantage. This apparent anomaly was discovered to be caused by the model's built-in assumption of zero price elasticity of demand. This was fully discussed in the subsection entitled, "Net present value versus the firm's initial share position", and supported by Appendix 4. No further explanation will be given here.

Perhaps the most important finding of Figure 5-13 is the ability of an experience curve slope advantage to overcome a poor initial market share position, and conversely the inability of high initial share to protect an SBU if the firm has an experience curve slope disadvantage. I believe these findings to be intuitively non-controversial. It makes sense that if the firm is more competent in the business (as measured by the relative experience curve slope), then a poor initial position in that business can be successfully overcome. The implication is important! The firm must invest the resources required to determine the competence of competitors before embarking on a strategy of market domination no matter what its initial market share position, assuming it is possible that experience curve slopes may vary among competitors.

The firm's initial market share vs the competitor's view of the product life cycle (S_A, R)

Figure 5-14, on the next page, shows isobars of constant net present value as a function of the firm's initial market share and the competitor's view of the product life cycle, assuming both participants have equal experience curve slopes, i.e., E_B = .75 and it is early in the product life cycle, i.e., N = 1.

As expected from previous work, NPV increases as the firm's initial market share increases and as the competitor's view of the market decreases. The isobars clearly point out that the main determinant on NPV in this matrix is market share. What little functional relationship there is between the firm's share and how the competitor views the market occurs mostly at high initial market share. However, as with the previous matrix, competitive knowledge does have value, particularly at moderate initial share positions, e.g., 60% share. Note, at that share level NPV goes from slightly negative if the competitor views the market as more attractive (i.e., R = 0) to slightly positive if the competitor views the market as less attractive (i.e., R = .30). Therefore, if the strategy to dominate the market appears marginal based on the firm's initial market share, research into how the competitor views the market

FIGURE 5-14. NPV = $f(S_A, R)$, N = 1, E_B = .75

COMPETITOR'S VIEW OF THE PRODUCT LIFE CYCLE

S_A (%)	.00	.05	.10	.15	.20	.25	.30
90	767	818	878	947	1021	1099	1179
80	627	699	785	884	990	1101	1216
70	230	318	420	538	665	799	937
60	-363	-268	-153	-23	117	266	418
50	-1150	-1051	-931	-795	-646	-490	-329
40	-2156	-2058	-1938	-1801	-1653	-1496	-1334
30	-3440	-3347	-3234	-3105	-2964	-2814	-2660
20	-5130	-5050	-4953	-4840	-4716	-4584	-4448
10	-7569	-7512	-7442	-7360	-7268	-7170	-7068

can be worthwhile.

The competitor's experience curve slope vs the competitor's view of the product life cycle (E_B, R)

Figure 5-15, on the next page, shows isobars of constant net present value as a function of the competitor experience curve slope and the competitor's view of the product life cycle, assuming it is early in the product's life cycle, as viewed by the firm, i.e., N = 1, and assuming the firm has an initial market share of 60%.

FIGURE 5-15. NPV = $f(E_B, R)$, N = 1, S_A = 60%

NPV=f(E_B,R), N=1, S_A=60%

COMPETITOR 'S VIEW OF THE PRODUCT LIFE CYCLE

E_B	.00	.05	.10	.15	.20	.25	.30
85%	10629	10322	10078	9914	9836	9835	9900
80%	3341	3353	3398	3478	3597	3727	3885
75%	-363	-268	-153	-25	117	266	418
70%	-2171	-2081	-1977	-1860	-1753	-1638	-1523
65%	-3014	-2952	-2881	-2806	-2729	-2652	-2577

As expected from previous work, the NPV of further investment in an SBU is high if the firm both has an experience curve slope advantage and sees the market as more attractive than does the firm. Also as expected, NPV will decline as the competitor's experience curve slope advantage increases and if the competitor sees the market as less attractive than does the firm.

Figure 5-15 is an interesting matrix. Consider that it shows that the firm's NPV of further investment in an SBU is strongly a function of the competitive environment, as suggested by Henderson (1979: 7,11). This is fully independent of the share and growth considerations felt sufficient by the Boston Consulting Group. It is clear that how the competitor views the market compared to the firm and how efficient the competitor is in reducing cost with experience compared to the firm are important determinants of the firm's NPV, as logic suggests.

Mapping conclusions

The results portrayed in this section are the heart of this thesis. The conclusions, as I see them, are twofold. First, the capital investment suggestions of the two variable matrices proposed by the Boston Consulting Group and McKinsey and Company cannot be fully supported by the mathematical model. However, there is certainly an element of truth in each.

Second, model results indicate that a two-variable description of factors affecting investment attractiveness is insufficient if it is possible that competition views the market differently than does the firm or if competition's efficiency in reducing cost through experience differs from that of the firm.

ANALYSIS BY MULTIPLE LINEAR REGRESSION

The previous section showed selected one and two variable maps of NPV. However, it is assumed in this thesis that NPV is a function of four variables. Since it is impossible to show functional relationships among four variables graphically, this section uses the statistical tool of multiple linear regression to more fully display the interrelationships of the variables within the model.

Considering the range of variation tested in each of the four factors proposed to influence NPV and the quantity of data output, a method is needed to summarize the findings beyond selected one and two variable maps. Also, if the results are to be generally useful to business any such summarization tool must be simple to understand. I propose multiple linear regression as such a tool. The goal of this analysis is to discover the importance of each variable in determining NPV, so that business might better select which current or potential SBU's have the highest probability of success for further investment, and so that business may better allocate competitive research expenditures.

First though, a word of caution about interpreting the results of analysis by multiple regression in this context. Generally, a regression analysis is applied to empirical data gathered by a researcher to test a hypothesis. The results of such an analysis are first the numerical values of a_0, a_1,....a_n in the equation:

$$y = a_0 + a_1x_1 + \dots + a_nx_n$$

The coefficients measure how each independent variable best combines to determine the dependent variable, assuming linearity. Second, the associated correlation coefficient, R^2, measures how fully the postulated relationship explains observed variations in the dependent variable, Y. The correlation coefficient in such analysis may be less than 1.0 if either all independent variables effecting Y are not included or the relationship is non-linear, or both.

Since this thesis is theoretical rather than empirical, the data analyzed results solely from applying capital budgeting theory to various standardized assumptions about conditions in an SBU and its competitive environment. Therefore, the coefficients in the regression equation are specific only to those standardized assumptions about the SBU and may have little general usefulness. Further, the correlation coefficients measure only the degree of nonlinearity in the relationship. They cannot, by construction, consider the possibility of missing independent variables.

It is not the goal of this section to calculated a general formula to describe NPV as a function of the four variables proposed. Such a goal would be suspect due to wide variation possible in conditions within an SBU and its competitive environment, especially size, length and shape of the product life cycle. It is the goal of this section to quantify how important each variable is in determining NPV. I propose that a reasonable way to accomplish that is through elasticity calculations from the results of multiple linear regression. Since the standardized assumptions regarding the SBU are, I believe, reasonable and comprehensive, such elasticities should be broadly applicable to the real world, at least within the limits of R^2.

All data points result from applying the standardized assumptions to capital budgeting theory, i.e., there is a direct functional relationship. Therefore, it is theoretically possible to calculate exactly how important each variable is in determining NPV by taking partial derivatives of NPV with respect to each variable in turn. Eventhough the functional relationship is very complex, approximation methods applied on modern high speed computers could calculate such partial derivatives to a high degree of accuracy. I have considered and rejected such an approach in favor of elasticities based on multiple linear regression, eventhough the partial derivatives approach would clearly be more academically elegant. The reason is that partial derivatives would be complex mathematically, difficult for practicing businessmen to appreciate and therefore unlikely to be applied in the real world. The elasticities proposed, on the other hand, are simple mathematically, easy to appreciate and more likely to be applied, eventhough they are only approximations.

To help smooth out the effects of inherrent non-linearity and to study interesting individual cases, I will present fifteen separate linear regression results. For reasons to be discussed later, the results will be broken into two parts: (1) cases where the experience curve slope is allowed to vary, and (2) cases where the experience curve slope is held constant.

Results with variable experience curve slopes

This subsection looks at nine cases where the experience curve slope is allowed to vary. They are:

1. All: All four variables, S_A, E_B, R and N, are freely allowed to vary (i.e., at least within the limits specified in the model input).

2. New Products: The variable N, the position in the product life cycle, is held constant at year one. The other three variables, S_A, E_B and R, are fully variable.

3. Equal View of the Market: The variable R, the competitor's view of the shape and size of the product life cycle, is held constant at the same level as the firm's. The other variables, S_A, E_B and N, are fully variable.

4. High Share: The variable S_A, the firm's initial market share, is limited to levels above 60%. The other variables, E_B, R and N, are fully variable.

5. Low Share: The variable S_A, the firm's initial market share, is limited to levels below 40%.

The other variables, E_B, R and N, are fully variable.

6. "Stars": The variable S_A is limited to levels above 50%, and the variable N, the position in the product life cycle, is limited to years below eleven. The other variables, E_B and R, are fully variable.

7. "Question Marks": The variable S_A is limited to levels below 60%, and the variable N is limited to years below eleven. The other variables, E_B and R, are fully variable.

8. "Cash Cows": The variable S_A is limited to levels above 50%, and the variable N is limited to years above ten. The other variables, E_B and R, are fully variable.

9. "Dogs": The variable S_A is limited to levels below 60%, and the variable N is limited to years above ten. The other variables, E_B and R, are fully variable.

Figure 5-16, on the next page, lists the regression equation, the associated correlation coefficient and the F-Test value for each case.

FIGURE 5-16 THE REGRESSION EQUATIONS, E_B VARIES

	COEFFICIENTS FOR:						
	S_A	E_B	R	N	CONSTANT	R^2	F
ALL	4564	17935	1002	7.3	5129	0.59	2176
NEW PRODUCTS	7778	30884	731	N/A	9098	0.77	354
EQUAL VIEW OF MARKET	4579	17824	N/A	9.9	5182	0.59	416
HIGH SHARE	-1806	11171	805	-95.1	8014	0.64	885
LOW SHARE	12560	22141	1038	126	3673	0.69	1446
"STARS"	-1145	18552	1251	-69.6	10352	0.75	1050
"?"	14461	30786	1297	78.3	6894	0.83	2068
"COWS"	-801	6790	506	-121	5784	0.59	457
"DOGS"	5635	12025	850	78.2	-5395	0.79	1489

Notice first the coefficients presented in Figure 5-16. From prior work, we would expect the following. Since S_A is a positive number (ranging 0.1 to 0.9) and since we expect that NPV increases with the firm's initial share, the coefficient of S_A should have a positive sign. Since E_B is a negative number (ranging -0.23447 for a 85% experience curve slope to -0.62149 for a 65% experience curve slope) and since we expect that NPV decreases as the firm's experience curve slope advantage declines, the coefficient of E_B should have a positive sign. Since R is a positive number (ranging 0.0 to 0.30) and since we expect that NPV increases as the competitor's view of the shape and size of the product life cycle decreases (i.e., as R increases), the coefficient of R should have a positive sign. Finally, as shown in Figure 5-1, the sign on the coefficient of N should logically vary. It should be negative in cases w there is positive NPV as NPV declines with the passage of time and it should be positive when there is negative NPV as NPV grows (i.e., becomes less negative) with the passage of time.

The coefficients presented in Figure 5-16 follow the described logic above for E_B and R. With respect to N, the logic holds except for the first and third cases. In both cases, while the coefficient of N is positive, the value of the coefficient is very small and since R^2 for both cases is only 0.59, the results are understandable, if not theoretically satisfying. As mentioned, we expect the coefficient of S_A to be positive, if increases in the firm's initial share position increase the NPV of further investment in the SBU. The results are as expected except for "Stars", "Cash Cows", and High Share cases. This anomaly is directly related to the built-in assumption of a zero price elasticity as shown in Figure 5-3 and Figure 5-13 and discussed there and in Appendix 4. To get a better look at the relationship among the variables for these high share cases, I have elected to present results of cases where the competitor's experience curve slope is held constant in the second part of this section.

Figure 5-16 also shows the correlation coefficients for each regression. Results indicate R^2 ranges from a low of 0.59 to a high of 0.83. As previously mentioned, R^2 in this context can only measure the degree of nonlinearity of the function and not the absence of important independent variables. Generally, the results of the correlations are not particularly high. Is this linear model sufficient as a useful tool? I believe it is, particularly when it is broken down into smaller, more linear segments like the BCG categories. Considering the degree of uncertainty involved in defining the product life cycle and understanding the competition, formulas that explain over two-thirds of the variation in NPV, based on wide variations in standard assumptions do not add appreciably to uncertainty. Finally, Figure 5-16 also lists F-Test results for each case. The value strongly rejects the null hypothesis at the 1% level.

Figure 5-17, on the next page, shows the results of average elasticity calculation of NPV with respect to

FIGURE 5-17 THE ELASTICITY RESULTS, E_B VARIES

ELASTICITIES OF NPV WRT:

	S_A	E_B	R	N	AVG NPV	R^2	#
ALL	30.6	101.5	2.02	0.98	74.5	0.59	5985
NEW PRODUCTS	49.0	164.2	1.38	n/a	79.3	0.77	315
EQUAL VIEW OF MARKET	39.4	129.3	n/a	1.70	58.1	0.59	855
HIGH SHARE	1.40	4.57	0.12	0.92	1030	0.64	1995
LOW SHARE	2.84	8.43	0.14	1.13	-1107	0.69	2660
"STARS"	0.58	5.29	0.13	0.93	1478	0.75	1400
"?"	3.87	11.59	0.17	0.38	-1120	0.83	1750
"COWS"	1.04	4.95	0.13	3.14	578	0.59	1260
"DOGS"	6.76	20.27	0.51	4.69	-250	0.64	1575

each variable. Point elasticities are calculated according to the equation:

$$\epsilon_{NPV,XN} = \frac{\partial\, NPV}{\partial\, X_N} \times \frac{X_N}{NPV}$$

To calculate average elasticities, the regression coefficient for the variable is assumed to approximate the partial derivative term, and the average of the variable over the range and the average NPV in the range are used to replace point estimates. Figure 5-17 also shows the average NPV, the R^2 and the number of data sets included in the case, all for reference. These average elasticities measure what percentage change occurs in NPV for a 1% change in the independent variable.

Notice first the elasticities of the two variables that refer to the competitive environment, E_B and R. NPV is always most sensitive to changes in the relative experience curve slope. In fact, in all cases the elasticity of E_B is higher than all other variables combined. NPV is always least sensitive to changes in how the competitor views the shape and size of the product life cycle, except for the "ALL" case, where it is next to last. The "ALL" case, however, has the lowest R^2 and therefore the results regarding R are at least suspect.

With respect to the elasticity of S_A, it is usually second most sensitive after E_B, except in "Stars" and "Cows" where the built-in assumption of zero price elasticity of demand causes distortions. The next part of this section clarifies those relationships.

Finally, NPV is generally not very sensitive to changes in the market growth rate, as measured by the position in the product life cycle, N. The only exceptions occur in the BCG categories "Cows" and "Dogs" where 1% changes in N produce 3%-5% changes in NPV.

A final comment about Figure 5-17. Notice how very sensitive NPV is to changes in S_A and E_B for the first three cases. In each case, the average NPV is low within the case thus magnifying sensitivity.

The results of the regression analysis and the associated elasticities are generally satisfying. The overall conclusion must be that the firm's relative experience curve slope is most important in determining the financial success of a strategy of dominating a market. And that the firm's initial market share is more important than the growth rate, given the experience curve effect. Somewhat surprising, the competitor's view of the product is relatively unimportant, at least when compared to the other three. The reason, undoubtedly, is that R is the only variable that does not effect the participant's relative cost position over time, and therefore a small price change can overcome a large difference in market perception.

Results with constant experience curve slope

This subsection looks at seven cases where the competitor's experience curve slope is held constant at the same slope as that of the firm. The cases presented are the same as those shown before with E_B held constant and the New Product and Equal View of the Market cases dropped. I have concentrated on those cases where the firm's initial share is included in the case definition, because as discussed, it appears that the combination of high initial market share and large experience curve slope advantage combine with the assumption of zero price elasticity to offset some of the advantages of relative share.

Figure 5-18, on the next page, lists the regression equation, the associated correlation coefficient and the F-Test value for each case, assuming both participants have equal experience curve slopes. While logic demands and the results of the previous subsection clearly shows the importance of relative experience curve slopes in determining NPV, I believe large differences in experience curve slopes are unlikely, at least among "world class" competitors in the same market. The section entitled, "Long-Run Cost Estimation and the Experience Curve", reviewed the implications of differences in experience curve slopes. I believe that this subsection's presentation of the importance of each variable in determining NPV is more realistic for practicing businessmen than the results of the previous subsection, as long as they believe all participants are equally competent or close to it.

FIGURE 5-18 THE REGRESSION EQUATIONS, E_B CONSTANT

COEFFICIENTS FOR:

	S_A	R	N	CONSTANT	R^2	F
ALL	5880	1017	103	-5196	0.70	945
"STARS"	2590	1410	-30.9	-1530	0.86	568
"?"	14355	1652	152	-8494	0.94	1972
"COWS"	655	337	-29.4	47	0.74	242
"DOGS"	5719	507	246	-6553	0.80	412
HIGH SHARE	996	817	-38.7	-153	0.86	850
LOW SHARE	12019	1077	247	-8203	0.88	1253

Notice first the coefficients presented in Figure 5-18. The sign on the coefficient of S_A is positive in each case, as expected. Since S_A is a positive number, NPV increases with the firm's initial market share. The sign on the coefficient of R is likewise always positive, and since the higher R is, the less the competitor thinks the market attractive, and the higher the firm's NPV. The sign of the coefficient of N varies. As already discussed the coefficient should be negative if NPV is positive and vice versa. The results are as expected. The signs of the regression coefficients make sense!

Figure 5-18 also shows the correlation coefficients for each regression. Results indicate R^2 ranges from a low of 0.70 up to 0.94. Again, the F-Test results, also listed, strongly rejects the null hypothesis at the 1% level of confidence. As expected, the R^2 improves substantially as the "ALL" case is broken down into smaller, more linear quadrants. The highest R^2 occurs in "?" SBUs and the lowest in "Cows". The conclusion must be that the function is most linear near N = 1 and S_A = 0.1 and least linear near N = 19 and S_A = 0.9 as demonstrated in Figure 5-7. Overall, the R^2 is much higher when variations in the highly nonlinear experience curve slope is excluded.

Figure 5-19, on the next page, shows results of average elasticity calculations of NPV with each variable when the competitor's experience curve slope is held constant. The format is as described for Figure 5-17.

Generally, NPV is most sensitive with respect to changes in the firm's initial market share, S_A. For "Stars", share is overwhelmingly the most important determinant of NPV. For "Problem Children", the dominance of share continues. Later in the product life cycle, the growth rate becomes more important. In fact for "Dogs" the growth rate, as measured by N, is almost twice as important in determining NPV. This is certainly as

FIGURE 5-19 THE ELASTICITY RESULTS, E_B CONSTANT

ELASTICITIES OF NPV WRT:

	S_A	R	N	AVG NPV	R^2	#
ALL	2.75	0.14	0.96	-1068	0.70	1197
"STARS"	4.79	0.54	0.43	393	0.86	280
"?"	1.39	0.08	0.27	-3104	0.94	350
"COWS"	3.32	0.34	2.98	148	0.74	252
"DOGS"	1.59	0.07	3.43	-1076	0.80	315
HIGH SHARE	2.10	0.32	1.00	380	0.86	399
LOW SHARE	1.17	0.06	0.96	-2569	0.88	532

expected. Early in the product life cycle, share is important in determining future costs. Later on, with slower growth, share differences have little influence on relative cost.

Interestingly, the competitor's view of the market, R, is the least important variable in all cases shown, except for "Stars". It is highly inelastic in all other cases, particularly when the firm's initial share is low. However, as might be anticipated, when we have a particularly attractive SBU, i.e., a "Star", then the competitor's opinion of that market assumes greater importance.

The general conclusions of this section are that (1) the firm's relative experience curve slope is most important in determining the financial attractiveness of a strategy of market dominance. A poor initial share position can be overcome if the firm can get costs down faster than competition. Even a high initial share position cannot protect the firm if it is incompetent. (2) Assuming that most competitor's are equally competent, then share usually dominates growth and competitive view of the market. (3) Splitting SBUs into the BCG quadrants adds information about the relative importance of each variable and increases linearity.

PRICING IMPLICATIONS OF THE MODEL

In the section "Limit Pricing", it was shown that the firm can discourage the competitor's further investment in an SBU with a correct pricing strategy. Considering that the competitor makes his investment decisions based partially on expected prices over the entire product life cycle, it was further shown that the firm needs to set a believable price pattern over time. the assumption of this thesis as described in the section "Integration of the tools" is that price will follow the firm's costs as a constant percentage markup. As discussed, that assumption is made because it seems most believable to the competitor and it follows the suggestions of the Boston Consulting Group.

It is the purpose of this section to:

* Describe again how a proper pricing strategy may be used by the firm to discourage competitive expansion.

* Demonstrate and interpret a proper pricing strategy given specified parameters about the competitive environment.

* Describe quantitatively what happens to the pricing pattern over time, assuming the firm is successful in discouraging competitive expansion.

Pricing strategy logic

It is assumed that the competitor makes investment decisions based on the net present value of incremental cash flows, and that the competitor will not invest further in an SBU if the net present value of such investment is at most zero. Since price is a major controllable variable, it makes sense that at some price (actually pricing pattern), the competitor will find the net present value unattractive. Of major importance in the model proposed in this thesis is the calculation of exactly that pricing pattern. The logic of that calculation follows.

The competitor's incremental cash flows from further investment in an SBU are the difference between what cash flows occur if he invests and if he fails to invest. If the competitor invests in the SBU at the same rate as the market, and he expects prices to fall in line with the firm's cost, then the competitor's costs will decline with his cumulative volume and the price will also decline, but in line with the competitor's cost, as well as the firm's cost. The reason is simple. If the competitor grows with the market, then both the firm and the competitor progress equally fast down the experience curve. If price is a constant percentage markup on the firm's cost, then it is also a constant percentage markup on the competitor's cost.

The competitor's earnings are then a function of his declining cost and the price pattern over time yet to be determined by the firm. The other component of cash flow is the competitor's investment requirements. Clearly, if the competitor expands sufficiently to maintain market share, it incurs negative cash flow. Combining properly the operating cash flows, which are a function of the unknown price pattern, and the investment requirement yields the net cash flows over time to the competitor if he expands with the market.

If the competitor elects not to expand, then his costs will decline, but not as fast as the firm's cost declines. The reason is simple. If the competitor does not expand and the firm does, the firm's growing relative cumulative volume will translate into a growing cost advantage. Further, if the competitor believes that price will be a function of the firm's cost, then he will predict lower prices if he fails to invest, along with higher costs and lower volume. Combining properly the competitor's estimate of his cost and volume along with the as yet unknown markup on the firm's cost yields the competitor's net cash flows over time if he elects not to expand. By definition there is no investment requirement if the competitor elects not to expand.

The problem from the perspective of the firm is to determine the proper percentage markup to discourage the competitor from investing. That percentage markup is the one that yields the competitor zero net present value on the competitor's incremental net cash flows. The model calculates that percentage markup and prints it out.

A pricing pattern case study

It is useful, at this point, to use a concrete example to clarify a proper pricing strategy. As an example, assume the firm's market share is 70%, the competitor's market share is 30%, the SBU is at the beginning of its product life cycle, and both the firm and the competitor view the product life cycle identically and have equal experience curve slopes. Under these conditions, the competitor is able to calculate his costs and the firm's both if he expands and if he does not. Figure 5-20, on the next page, sets out those costs, based on the "standard" assumptions.

Since the competitor can calculate both his and the firm's cost position over time under each option, his decision on investing in the SBU is a function of what price the firm sets in year one, assuming the competitor believes that the markup implied by the announced price will be maintained by the firm over the entire product life cycle. The model logic calculates the correct price that the firm should set is $48.09, a 59.5% markup on its cost.

With an implied 59.5% markup on the firm's cost, the competitor is able to calculate the price pattern it

FIGURE 5-20. COST PATTERNS IF THE COMPETITOR EXPANDS VS IF THE COMPETITOR DOES NOT EXPAND

	COMPETITOR EXPANDS		COMPETITOR DOES NOT EXPAND	
YEAR	FIRM'S COST	COMPETITOR'S COST	FIRM'S COST	COMPETITOR'S COST
1	30.15	42.86	30.15	42.86
2	19.11	27.17	18.08	32.15
3	14.33	20.37	13.22	27.17
4	11.60	16.48	10.54	24.11
5	9.80	13.93	8.83	21.98
6	8.52	12.11	7.63	20.38
7	7.56	10.75	6.74	19.11
8	6.81	9.68	6.05	18.08
9	6.21	8.83	5.50	17.22
10	5.71	8.12	5.04	16.48
11	5.30	7.53	4.67	15.84
12	4.94	7.03	4.35	15.28
13	4.64	6.59	4.07	14.78
14	4.37	6.21	3.83	14.33
15	4.13	5.88	3.62	13.93
16	3.92	5.58	3.44	13.56
17	3.74	5.31	3.27	13.22
18	3.57	5.07	3.12	12.91
19	3.42	4.86	2.98	12.63
20	3.28	4.66	2.86	12.36

expects, both if the competitor expands and if he does not expand. Figure 5-21, on the next page, sets out those price patterns based on the firm's cost and the markup.

When the competitor calculates the net cash flow from each option, given the implied price pattern and his investment requirements if he expands, and calculates his net present value it will be zero. The reason is simple. The firm has made the identical calculation with its unknown percentage markup that makes the competitor's net present value zero.

The theoretical result of the firm's initial price of $48.09 is, as expected, that the competitor will not invest in maintaining market share. The implied pricing pattern entitled "Competitor Does Not Expand" in Figure 5-21 will hold and the model calculates the firm's net present value of that strategy as positive $538. Therefore, given the conditions of this cast study, such a pricing strategy is attractive to the firm. Figure 5-22, on the next page, shows the firm's costs and the price over the product life cycle, assuming success in discouraging competitive investment.

<u>Actual pricing pattern held over time</u>

As discussed in the section, "Limit Pricing", temporary success in discouraging competitive investment make the job of discouraging him in the future easier. The business is now basically less attractive to the

FIGURE 5-21. PRICE PATTERN IF THE COMPETITOR EXPANDS VS IF THE COMPETITOR DOES NOT EXPAND

	PRICE PATTERN IF:	
YEAR	COMPETITOR EXPANDS	COMPETITOR DOES NOT EXPAND
1	48.09	48.09
2	30.48	28.84
3	22.86	21.09
4	18.50	16.82
5	15.63	14.08
6	13.59	12.17
7	12.06	10.75
8	10.86	9.65
9	9.90	8.77
10	9.11	8.05
11	8.45	7.44
12	7.88	6.93
13	7.40	6.50
14	6.97	6.11
15	6.59	5.78
16	6.25	5.48
17	5.97	5.21
18	5.69	4.98
19	5.45	4.76
20	5.23	4.56

competitor as his cost disadvantage widens and the time left to "enjoy" the market is shortened. The model calculates the percentage markup on the firm's cost for each year, assuming in discouraging competitive investment.

FIGURE 5-22. FIRM'S COST AND PRICE OVER THE PRODUCT LIFE CYCLE

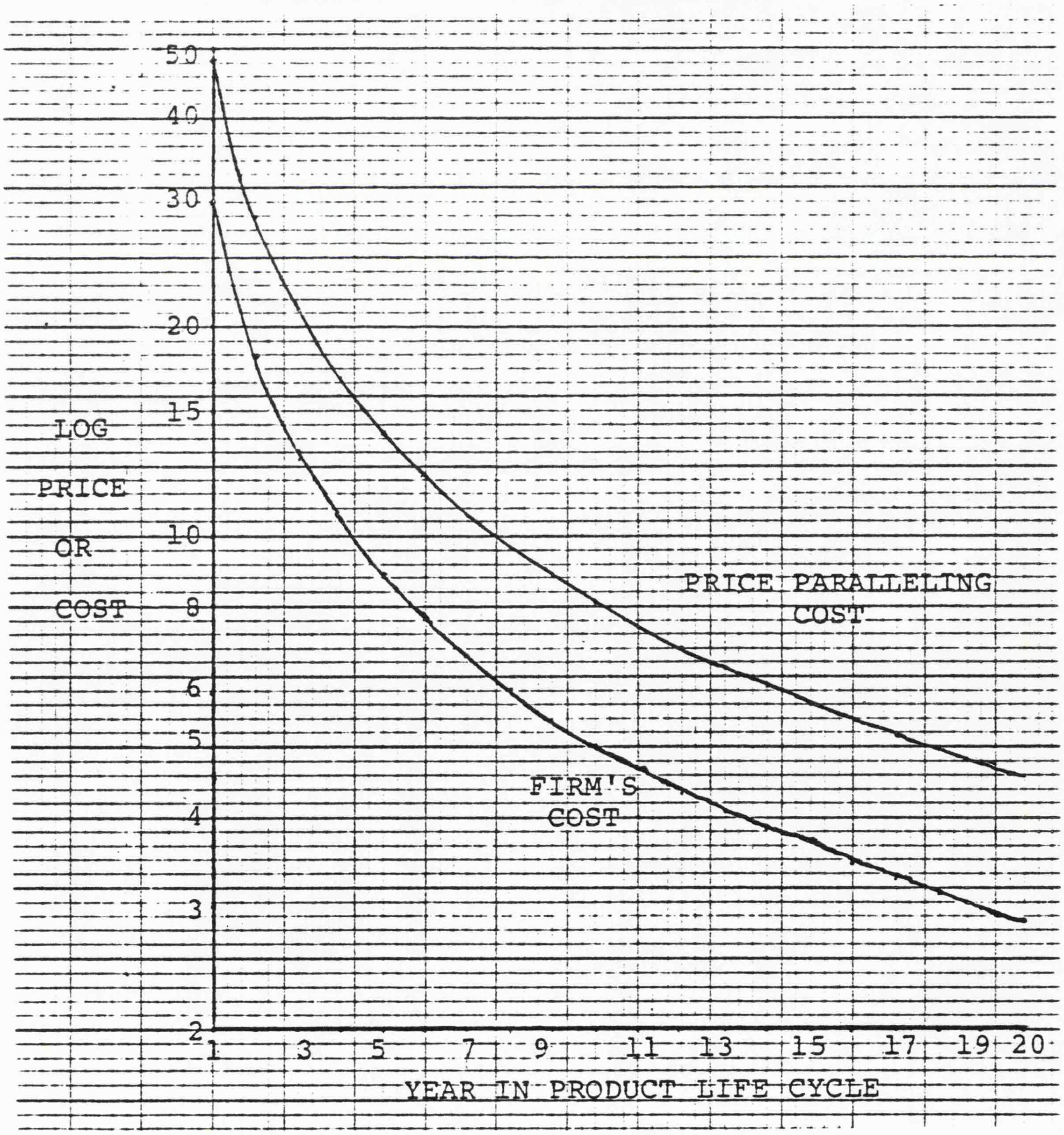


Figure 5-23, on the next page, shows the calculation of the actual price pattern as a function of the firm's cost pattern and the percentage markup on the firm's cost calculated by the model to discourage competitive investment. The results are based on the same conditions described in the preceding subsection.

Notice, only nineteen years data is shown. Since calculations are based on incremental economics between the current position and the next year, and there is a twenty year product life cycle, there are nineteen data points. At the absolute end of the product life cycle, even an extremely high price would not encourage the competitor to expand. The reason is that any investment requires a cash outflow; and since the model assumes no salvage value, no investment, no matter the price, will be made, since any such investment will be immediately obsolete.

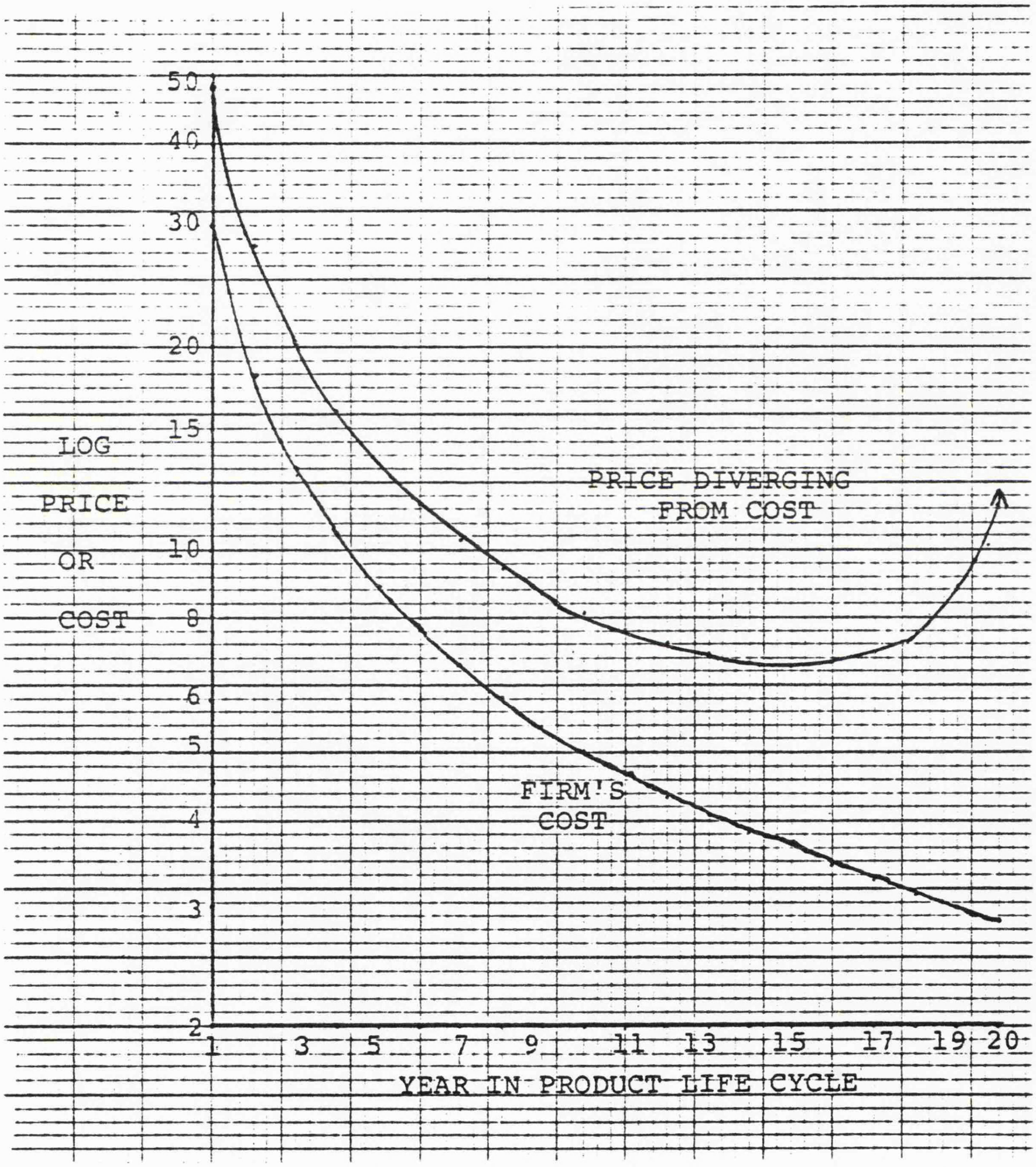
Figure 5-24, on the second following page, shows graphically the actual price pattern and the firm's cost over time. As time passes, actual price diverges from the firm's cost as first theorized in the section, "Integration of the Tools". However, as previously mentioned, the price the firm actually received is a function of the cost-in-use of the best substitute. Clearly, the price will not approach infinity as the life cycle ends. Product users will substitute other products which are more reasonably priced.

FIGURE 5-23. ACTUAL PRICE PATTERN AND THE FIRM'S COST IN TABULAR FORM

YEAR	FIRM'S COST	MARKUP PERCENTAGE	PRICE
1	30.15	59.5	48.09
2	18.08	54.7	28.12
3	13.22	52.8	20.20
4	10.54	52.2	16.04
5	8.83	52.3	13.45
6	7.63	53.0	11.67
7	6.74	54.2	10.39
8	6.05	55.8	9.43
9	5.50	57.9	8.68
10	5.04	60.5	8.09
11	4.67	63.7	7.64
12	4.35	67.7	7.29
13	4.07	72.7	7.03
14	3.83	79.1	6.86
15	3.62	87.4	6.78
16	3.44	98.8	6.84
17	3.27	115.5	7.05
18	3.12	142.6	7.57
19	2.98	195.5	8.81

FIGURE 5-24. ACTUAL PRICE PATTERN AND THE FIRM'S COST

IN GRAPHICAL FORM



Finally, at this point it is logical to comment on one final assumption made that affects all net present value numbers calculated by the model. A decision had to be made as to the price pattern to be used in calculating NPV. The three options are:

1. The pricing pattern assumptions used to create the price pattern shown in Figure 5-22. That is, price parallels the firm's cost.

2. The pricing patter assumptions used to create the price pattern shown in Figure 5-23. That is, price diverges from the firms cost and heads for infinity.

3. Something in between 1 and 2, above.

Option 2 clearly becomes ridiculous, particularly as the product life cycle ends. Option 3, while intellectually satisfying, requires the model to assume not only the current cost-in-use of the best substitute product, but how the substitute product's cost-in-use declines over time. Option 1 is the lowest price pattern and therefore the most conservative. Eventhough it is probably too conservative for the real world, it is the pricing pattern used by this model to calculate all net present values. What Option 1 implies is that the product provided by the SBU is only marginally better for customers than the next best available substitute and that both the product's and the substitute's cost decline over time in the same fashion. If the real world demands it, any appropriate substitute product's cost-in-use decline pattern could be substituted in the model with minor adjustments and no decline in theoretical accuracy.

CHAPTER 6

A WRAP UP

Chapter 6 is designed to be the chapter in which all "loose ends" remaining are finally tied. Since this work is theoretical, I have elected to attempt to lend support to its conclusions by comparison to the PIMS study. Since this work is heavily dependent on the existence of the experience curve, I have elected to include a section on the results if the experience curve does not exist. Since I have preliminarily proposed that further investment in "Stars" does not always have the highest NPV, but is heavily dependent on how the competitor views the market, a final clarification is needed. And, since it is traditional, I have included a section in which I suggest areas for further research.

THE RELATIONSHIP OF THIS THESIS TO PIMS RESULTS

The purpose of this section is to compare and contrast the theoretical findings of this thesis with the empirical results found by the PIMS project. It seems obvious that if this thesis' findings are valid, it cannot conflict with PIMS results.

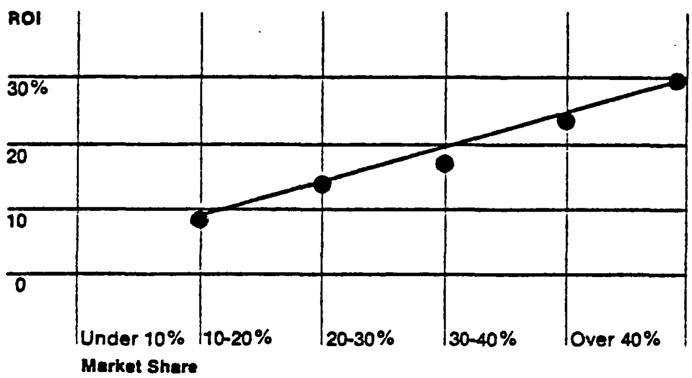
According to Buzzell, et al (1975:97),

> "It is now widely recognized that one of the main determinants of business profitability is market share. Under most circumstances, enterprises that have achieved a high share of the markets they serve are considerably more profitable than their smaller share rivals...On average, a difference of 10 percentage points in market share is accompanied by a difference of about 5 points in pretax ROI."

In support of that last comment Buzzell, et al (1975:98) shows graphically the relationship between market share and pretax ROI, which I have reproduced as Figure 6-1, on the next page.

As a comparison, I have calculated average NPV over the entire product life cycle, assuming market participants have equal experience curve slopes and view the market identically. Results are summarized in the table below Figure 6-1.

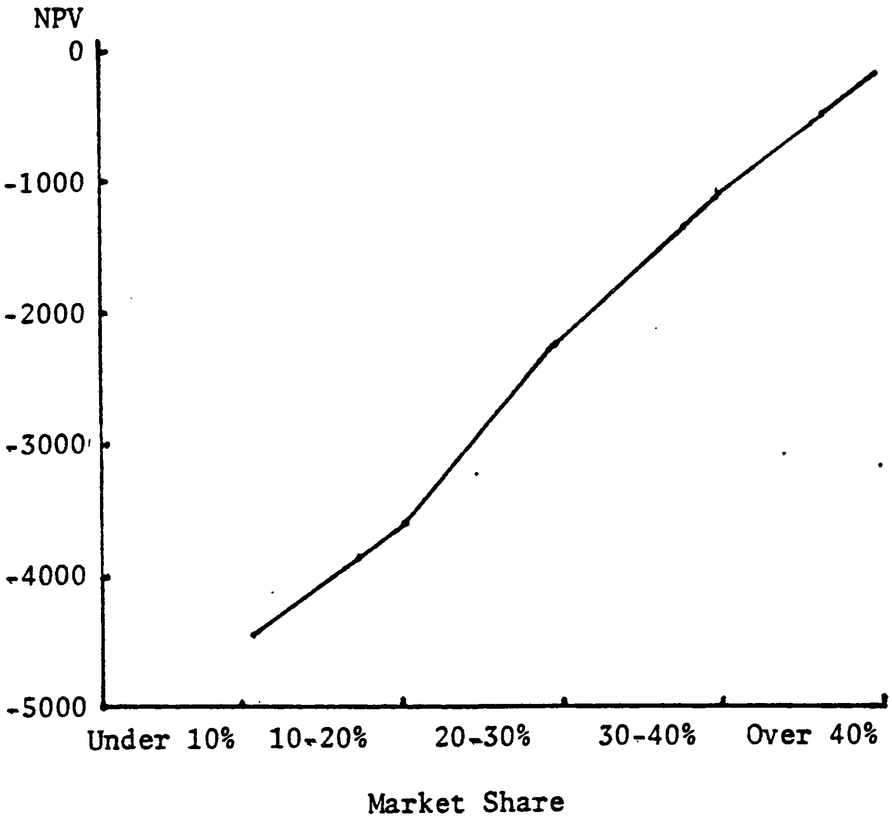
FIGURE 6-1. PIMS RELATIONSHIP BETWEEN MARKET SHARE AND PRETAX ROI



FIRM'S INITIAL MARKET SHARE	AVERAGE NPV OVER LIFE CYCLE
10%	-4649
20%	-2875
30%	-1778
40%	-1011
50%	- 451
60%	- 40
70%	248
80%	421
90%	451

I have combined these into categories approximating Figure 6-1 by assuming Buzzell's 10-20% market share can be the average of my 10% and 20% market share, etc. The results are graphed in Figure 6-2.

FIGURE 6-2. THESIS RELATIONSHIP BETWEEN MARKET SHARE AND AVERAGE NPV



The results are interesting. First, the relationship is highly linear, as found by PIMS. Second, eventhough I am using NPV instead of ROI as the y-axis, it appears the profitability measure is reasonable. Note, the NPV when market share is over 40% is about zero, actually -382. Since the thesis assumes a 15% cost of capital to discount the firm's cash flows to net present value, and the thesis assumes a 50% tax rate, a zero NPV translates into a 30% "pretax IRR". PIMS results, as shown in Figure 6-1, show pretax ROI when market share is over 40% to be slightly less than 30%, consistent with this work.

Buzzell, et al (1975:99) reports that the main difference in ROI between high and low share businesses is caused by profit margin differences, not asset turnover differences or capacity utilization rates. Their findings are summarized below:

MARKET SHARE	INVESTMENT TO SALES (%)	CAPACITY UTILIZATION (%)	PRETAX PROFIT TO SALES (%)
Under 10%	68.66	74.7	-0.16
10-20%	67.74	77.1	3.42
20-30%	61.08	78.1	4.84
30-40%	64.66	75.4	7.60
Over 40%	63.98	78.0	13.16

As mentioned, this model calculates a price pattern designed to discourage competitive expansion based on a constant markup on the firm's cost. The size of that markup can be used as a surrogate to measure changes in profit margin as a function of share. The thesis results, shown on the next page, demonstrate that profit margin grows dramatically as share increases, assuming equal experience curve slopes and equal views of the product life cycle, as observed by the PIMS study.

FIRM'S INITIAL MARKET SHARE	PRICE AS % OF FIRM'S COST
10%	0.409
20%	0.590
30%	0.753
40%	0.919
50%	1.101
60%	1.316
70%	1.595
80%	2.010
90%	2.834

With respect to the other factors affecting ROI, the model as constructed allows for no differences based on share. For example, since the model assumes capacity can be added continuously rather than in discrete "lumps", both participants always operate at 100% of capacity. And, since the cost of capacity is a function of the experience curve and sales are also a function of the experience curve, no difference can exist in the investment to sales ratio.

The thrust of this thesis is clearly to study the economics of changing market share using a pricing strategy to limit competitive expansion. Since Buzzell, et al (1975:104) relate PIMS results on how ROI is affected by market share changes, it seems worthwhile to make the comparison. I have reproduced their findings as

Figure 6-3.

FIGURE 6-3. PIMS RESULTS ON

HOW ROI IS AFFECTED BY MARKET SHARE CHANGES

Market share 1970	Market-share strategies Building: up 2 points or more	Holding: less than 2 points up or down	Harvesting: down 2 points or more
	Average ROI, 1970-1972		
Under 10%	7.5%	10.4%	10.0%
10%-20%	13.3	12.6	14.5
20%-30%	20.5	21.6	9.5
30%-40%	24.1	24.6	7.3
40% or over	29.6	31.9	32.6

Their most consistent relationship is that ROI suffers, at least temporarily, when a strategy of building market share is implemented. Since this thesis is designed to calculate cash flow required for net present value, rather than income statements and balance sheets required to calculate ROI, I have elected to recalculate only one case to check this thesis and PIMS findings. In fact, such recalculation requires additional assumptions. For instance, in the model I have assumed that all capital investment is immediately expensable rather than being capitalized and depreciated. With that assumption, net fixed assets are always zero and ROI would approach infinity. To simulate a more realistic financial accounting system, I have assumed that assets are capitalized as acquired and are depreciated over a ten-year life on a straight line basis assuming no salvage value.

Using that assumption I have calculated earnings and investment for the case where the firm's initial share is 70% and where both market participants have equal experience curve slopes and equal views of the product's life cycle. Taking a typical year, say year 10 of the product life cycle, calculations show an ROI of 37.1% if the firm implemented a strategy of gaining market share versus an ROI of 38.7% for a strategy of maintaining market share. Averaging all twenty years, for this case, shows ROI about 0.7% less with a strategy of building market share when compared to a strategy of maintaining market share. This is consistent with the Buzzell, et al (1975:103) report that:

> "Generally, the businesses that were 'building' (i.e., had share increases of at least 2 points) had ROI of 1 to 2 points lower than those that maintained more or less steady ('holding') positions."

Finally, Woo (1984) used PIMS results to contrast 48 low performing market share leaders (which had pretax ROIs of less than 10%) with 71 high performing market share leaders (pretax returns exceeding 40%) to determine why the benefits of market share dominance were not universally enjoyed. This thesis contends that increasing market share is attractive financially, at least as long as the firm has reached the initial "critical mass" of market share. A review of her findings compared to thesis assumptions is worthwhile.

Woo (1984) found low performing market share leaders tended to have the following characteristics:

1. Slower growth markets -- 3% growth vs 5% growth for high performers.

2. Highly fragmented market -- 24% in markets with twenty or more competitors vs 8% for high performers.

3. High product and technology changes.

4. A market with exiting competitors.

5. Low value added.

6. Poorer reputation for quality.

7. Tendency to charge higher prices than competition.

8. Tendency to have higher costs than competition.

None of these conditions fit this model except, interestingly, #8! The market growth rate is always higher than 5%. There are only two participants in the market. Neither participant faces difficult product or technology changes. No participants exit the market. All of the value is added by the participants. The model allows for no product quality or price differences.

As long as competitors have equal experience curve slopes, the market share leader has, by definition, lower cost. However, this thesis allows differences in experience curve slopes. One of the primary findings of this work is that a higher initial market share cannot protect the firm if it is incompetent relative to its competitors. Woo's (1984) study corroborates!

ADJUSTMENTS TO THE THEORY IF EXPERIENCE CURVES DO NOT EXIST

In the section entitled "Long-Run Cost Estimation and the Experience Curve", both Hart's (1983) and Hall and Howell's (1983) criticism of the experience curve were reported. Basically, they argue that the experience phenomena does not exist because cost declines can be statistically explained using current volume (i.e. scale factors) instead of cumulative volume (i.e. experience). In that section, I promised to address the effect on the model if such criticism proves to be true. This section fulfills that promise.

Again, this thesis assumes that the net present value to the firm of further investment in an SBU is a function of the position in the product life cycle (N), the firm's relative market share (S_A), the competitor's view of the product life cycle (R) and the relative slopes of the participants' experience curve (E_B). That is:

$$NPV = f(N, S_A, R, E_B)$$

The chapter entitled, "Mapping Results", reported that NPV increases if it is early in the product life cycle and if the firm's relative share is high, as predicted by the Boston Consulting Group. Further, the model predicted that the firm's NPV of further investment in an SBU will be high if the competitor views the market as less attractive than does the firm and if the firm has an experience curve slope advantage.

What if the experience curve does not exist? What if cost declines as a function only of current scale? If so, the importance of current relative market share and future relative market share may under certain conditions still be important. The value of past relative market share is zero. Before proceeding further, let us examine the conditions under which current and future relative market share are important.

If scale factors alone determine cost, then the value of market share must be a function of minimum economic scale. Assume a market size of 300 units with a minimum economic scale for production facilities of 200 units. If the firm has a two-thirds share, then he will have a cost advantage at least as long as it takes the competitor to reach a sales volume of 200 units through market growth, assuming share remains constant. However, if technological advances increase the minimum economic scale over time, that cost advantage may persist. In contrast, if the minimum economic scale if only 50 units in a 300 unit market, then a two-thirds share provides no cost advantage. Therefore, without the experience curve, the importance of relative market share is strongly dependent on minimum economic scale, and changes in minimum economic scale with changes in technology.

Eventhough cost advantages may persist as a function of market share even without the experience curve phenomena, it seems obvious that the value of market share in determining attractive investment opportunities in SBU's will decline, if experience curves do not exist. As already mentioned, since this thesis elects to assume the existence of experience curves, no attempt will be made to quantify that potential reduction in the value of market share.

The second major way in which experience curves enter the model is through changes in the relative slopes of the participant's experience curve, the variable called E_B. An experience curve slope measures how efficient a competitor is in reducing cost through experience. If one competitor has a steeper experience curve slope than another, then his costs will decline further for an equal change in cumulative volume. And, a cost advantage will persist without the influence of market share.

Is anything analogous possible if experience curves do not exist? Of course! Varying experience curve slopes are nothing more conceptually than measuring the efficiency of a competitor, or as McKinsey might call it, their "business strength". Without experience curves, cost positions over time are determined by long-run average cost curves, which are simple envelopes enclosing successive short-run average cost curves. Could a cost advantage over competitor's persist without the experience phenomena? Certainly; if one competitor had a lower long-run average cost curve and could maintain it over time. Assume that were possible, eventhough there are good arguments that it isn't, just as there are good arguments that long-run differences in experience curve slopes cannot persist. How would differences in "efficiency" between competitors influence the investment attractiveness of an SBU?

Without experience curves, cumulative volume does not effect cost and assuming scale does not change, cost differences based on efficiency remain constant. For example, assume the sales volume for each firm is 100 units per year and sales remain constant over time. Further assume that one competitor's cost is $10 and the other's is $12, the difference based on difference in the positions of long-run average cost curves. Ten years later, the cost difference is still $2, assuming scale has not changed. On the other hand, assume experience curves do exist and the initial assumptions still hold; however assume that efficiency is measured by experience curve slope, and the competitor with a $10 initial cost has a 70% experience curve slope, while the competitor with a $12 initial cost has only a 75% slope. Ten years later, experience curves would predict cost declines such that only a $1.56 difference in cost would remain instead of a $2 difference without experience curves.

The conclusion, perhaps, is that efficiency differences based on differences in long-run average cost positions are more important than efficiency differences based on different experience curve slopes, particularly in slowly growing businesses. Again, as with market share, no attempt will be made here to quantify the relationship.

The other two variables -- the current position in the product life cycle as viewed by the firm (N), and the competitor's view of the product life cycle (R) are not influenced by the existence of the experience curve. They both are market rather than cost oriented. Therefore, their importance in determining the investment attractiveness of an SBU should be uninfluenced by the existence of experience curves.

FURTHER DISCUSSION OF THE NPV OF "STARS" AS A FUNCTION OF THE COMPETITIVE VIEW OF THE PRODUCT LIFE CYCLE

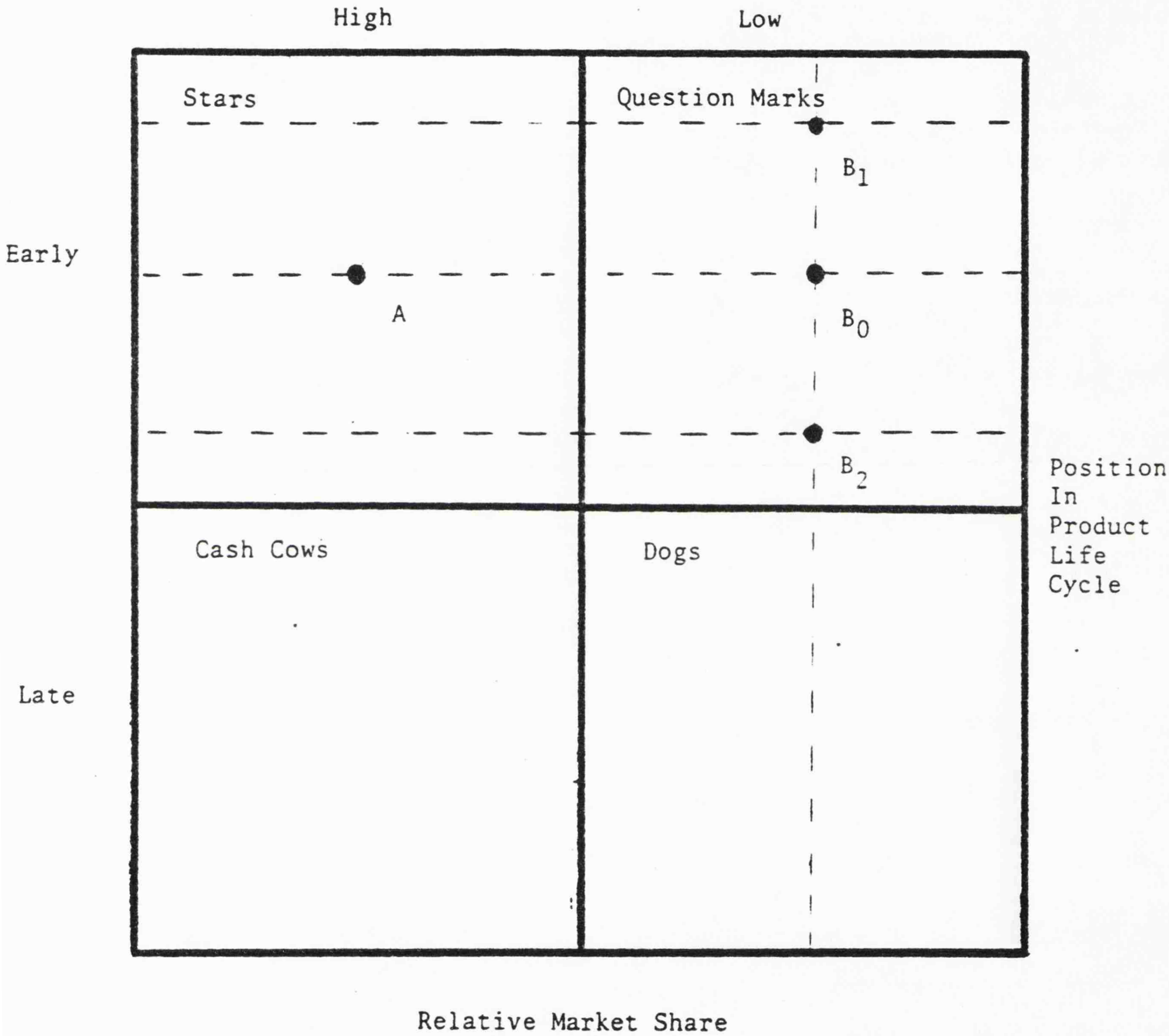
As first mentioned in the subsection entitled, "Usefulness of portfolio matrix analysis", it seems logical that "Stars" are the highest value SBUs to the firm, since by definition, a "Star" has a long remaining life and it enjoys a cost advantage over competition. However, it also appears logical that a case can be made that the NPV of further investment by the firm is not necessarily high for "Stars", and is a function of how the competition views the current position in the product life cycle and his likely investment action based on that assessment. This section fulfills the promise made to investigate and comment further.

As a basis for further discussion, allow me to reproduce the argument. Assume a simple competitive environment with only two players, the firm (A) and a competitor (B), and allow the transformation of the BCG's "growth" axis into position in the product's life cycle. Figure 6-4, on the next page, shows the position on the matrix of the firm at A and therefore the firm's estimate of the competitor's position at B_0. Two alternate positions for the competitor are also shown depending on how he views the product. Note, there can be no argument about the current relative market share, and therefore the relative cost position if the experience curve effect is in force. But reasonable men can differ on the position in the product life cycle, primarily based on their ability to understand the market. At B_1, the competitor believes it is very early in the life cycle. At B_2, he believes it is much later, even later than the firm suspects.

Will the competitor's response vary depending on whether he views his position as being B_1 or B_2? Likely so -- the competitor is much more apt to select the business for further support if he believes the business is located at B_1 instead of B_2. As previously discussed, the way a firm moves a "Problem Child" product toward becoming a "Star" is to invest in market share. Generally, a competitor selecting one of his "Problem Child" to challenge this firm's "Star" will

FIGURE 6-4.

COMPETITOR'S EFFECT ON INVESTMENT ATTRACTIVENESS



result in lower prices and/or higher costs and therefore lower earnings and cash flow for the "Star".

Logically, there are basically two extremes in incremental cash flow that the firm can expect from further investment in its "Star". They depend primarily on whether and to what extent the competitor desires to increase share. Let's look in more detail at those two extremes.

The firm's present value of further investments in it "star" business, given the competitor thinks that his position is at B_1, is very high. A look at the firm's incremental cash flow position for investing versus not will show why. If the firm invests, it will likely maintain share and therefore volume; and if the "experience curve" effect is in operation, it will also maintain a cost advantage over its competition. If it fails to invest, and the competitor does as he is likely to do, the firm will lose share and volume, and the cost advantage will deteriorate. The difference between those two scenarios is likely to produce large incremental cash flows and therefore a large present value for further investment in the "Star" business.

Conversely, the present value of further investment by the firm, given the competitor thinks that his position is at B_2 is not nearly so high. Again, an incremental cash flow analysis tells the story. If the firm invests and the competitor does not, it is true that the firm's market share will grow and its cost advantage on the experience curve will widen. However, if it fails to invest and the competitor does not fill the void, no volume will be lost and prices might even improve as product scarcity takes over. Further, the firm's operating rates, i.e. operation as a percent of capacity, would likely improve thus lowering costs. The total effect may well be only a small incremental cash flow and therefore a low present value of further investments in the "Star" business.

The argument is logical, but it is flawed because it relies on the erroneous investment directions of the Boston Consulting Group. They say that certain "Problem Children" SBUs should be invested in with the intention of transforming them into "Stars". This thesis clearly shows that "Problem Children" are incorrigible! That is they can not be profitably converted into "Stars" if market share must be bought by price, or price equivalent competition. This is best shown in the Chapter 5 subsection entitled, "Position in the product life cycle vs. the firm's initial market share (N, S_A)".

Therefore, if competition were aware of the unattractiveness of further investment in their "Problem Children", it is unlikely they would make such investment even if they believed the product to be much earlier in its product life cycle than does the firm. This is best shown in the Chapter 5 subsection entitled, "The firm's initial market share vs. the competitor's view of the product life cycle (S_A, R)".

The only exception to these findings is if the competitor believes he is more competent than the firm, i.e., has a steeper experience curve slope. In that case the competitor can justify investment in "Problem Children" SBUs. This is best shown in the Chapter 5 subsection entitled, "The firm's initial market share vs. the competitors experience curve slope (S_A, E_B)".

The implications of this section are major. First, if both participants in the market operate under the erroneous investment directives of the Boston Consulting Group, then firms that invest in low share SBUs with the intention of developing "Stars" will generally find their investments financially unattractive; and further, their pricing actions to buy share will at least partially destroy the benefit of high share to the dominant firm. Again the murder and suicide analogy.

Second, if the dominant firm alone is operating under the BCG directives, it may place too much importance on how its low share competitors view the products position in its life cycle. It may be too conservative in its investments in its "Star" product, or it may devote too many resources to discovering what its competitors think of the product.

However, if all participants operate under the same correct rules, "mistakes" can be avoided and scarce corporate resources can be channeled to their most productive uses.

SUGGESTIONS FOR FURTHER RESEARCH

In a theoretical thesis, particularly one that proposes a complex model for the real world, suggestions for further research seem to present themselves with great regularity as the work progresses. For presentation purposes, I have elected to organize those suggestions into three classes -- theoretical, modeling, and experimental.

Theoretical

With respect to theory, this thesis made three major assumptions. It assumed that financial theory could provide an appropriate cost of capital with which cash flows can be discounted to net present value. As mentioned in the section entitled "Traditional Capital Budgeting Theory, Similarities and Contrasts to Strategic Planning", significant controversy remains regarding the cost of capital. The conclusions presented in this thesis are certainly influenced by the cost of capital. Appropriate conclusions in the real world await settlement of that issue.

The thesis assumes that the market includes only the firm and one competitor. This assumption was made necessary because limit pricing theory is designed to consider pricing based on the economics of one competitor if experience curve effects are important. As mentioned in the section entitled "Limit Pricing", if there are multiple large scale competitors, then intermediate cost competitors must be discouraged from expansion not only by the limit price but by threat of retaliation by the low cost producer if they expand. Further work is needed to define how such threats may be made meaningful and predictable.

Perhaps most importantly, this thesis is built on the assumption that the experience curve phenomena exists. Recent criticism deny its existence. Even considering the limited data on which the criticism is based and the lack, so far, of extensive academic debate, the critics' points are well made. While I personally believe that experience curves do exist, and that scale expansion is an important part of it, further academic debate and research are sorely needed to settle this important question.

Modelling

The model proposed in this thesis is naturally a compromise between what should be done to most fully describe the variables and conditions that determine the attractiveness of further investment in an SBU and what can be done considering limited time and a sincere desire to limit the scope of the work to a reasonable size. Given unlimited resources and time, I would suggest the following changes in the model to make it more "real worldly".

First, with respect to the assumed product life cycle, I would suggest a bell-shaped curve for industry sales versus time instead of the right triangle used in the model. Clearly, a more realistic product life cycle would yield more believable results. Further, it would allow a test of the effect of declining sales on the NPV of the firm's investments in SBUs. This would allow a full critique of the McKinsey matrix. Also, the model assumed that the competitor views the market as having the same shape and length as the firm. More realistic would be varying the competitor's view of shape and length, as well as the size of the product life cycle.

Second, the model assumes that no matter when capital investment is required, such assets last until the end of the product life cycle. More reasonable would be the assumption that capital assets have a more limited life and that such assets have a residual value on disposal. Further, the model assumes no working capital investments requirement. More reasonable would be the assumption that working capital requirements grow during the growth stage and decline as the product matures.

Third, the model assumes a continuous world in which both prices and capacity can be changed incrementally. More realistic would be adjustments that allow the inclusion of pricing focal point and minimum economic scale for capacity expansions.

Fourth, the model assumes both a constant cost of capital between the firm and its competitor and a constant cost of capital over time. Assuming the traditional view on the cost of capital, it seems most logical that capital costs could vary between participants based on varying debt to equity ratios as determined by varying corporate risk preferences. Undoubtedly, such differences would be important in determining SBU investment attractiveness. Furthermore, over such long periods of time as implied by the full product life cycle of an SBU, capital costs would be expected to vary. Particularly considering the historically high current cost of capital, variations in such costs would be a useful refinement.

Finally, the model assumes a zero price elasticity of demand. Much more useful would be a functional relationship between the quantity demanded and the price level, perhaps also related to the position in the product life cycle.

Experimental

The true test of a theoretical proposal is its reasonableness in the real world. As such a test, I propose the following. First, do the conclusions of the model, fully explained, make sense to the decision makers in the real world? I, naturally, predict the answer is yes! The conclusion that the firm's competence in the business (as measured by its relative experience curve slope) is most important can not be controversial. The conclusion that share is more important than growth makes sense if relative costs are more a function of share than growth. Finally, the conclusion that the competitor's view of the market is least important is logical once we realize that this is the only variable that is not influenced by the experience curve and therefore does not influence relative cost positions in the future.

Finally, and most likely most importantly, further researchers should look for evidence that investments made with characteristics predicted by the model as those yielding highest NPV actually perform as predicted. Again, that should be those investments with the longest expected remaining life, those with the highest initial share for the firm, those that the firm believes the competitors view the market as less attractive than the firm and those in which the firm is believed to have an experience curve slope advantage.

LIST OF APPENDICES

APPENDIX 1

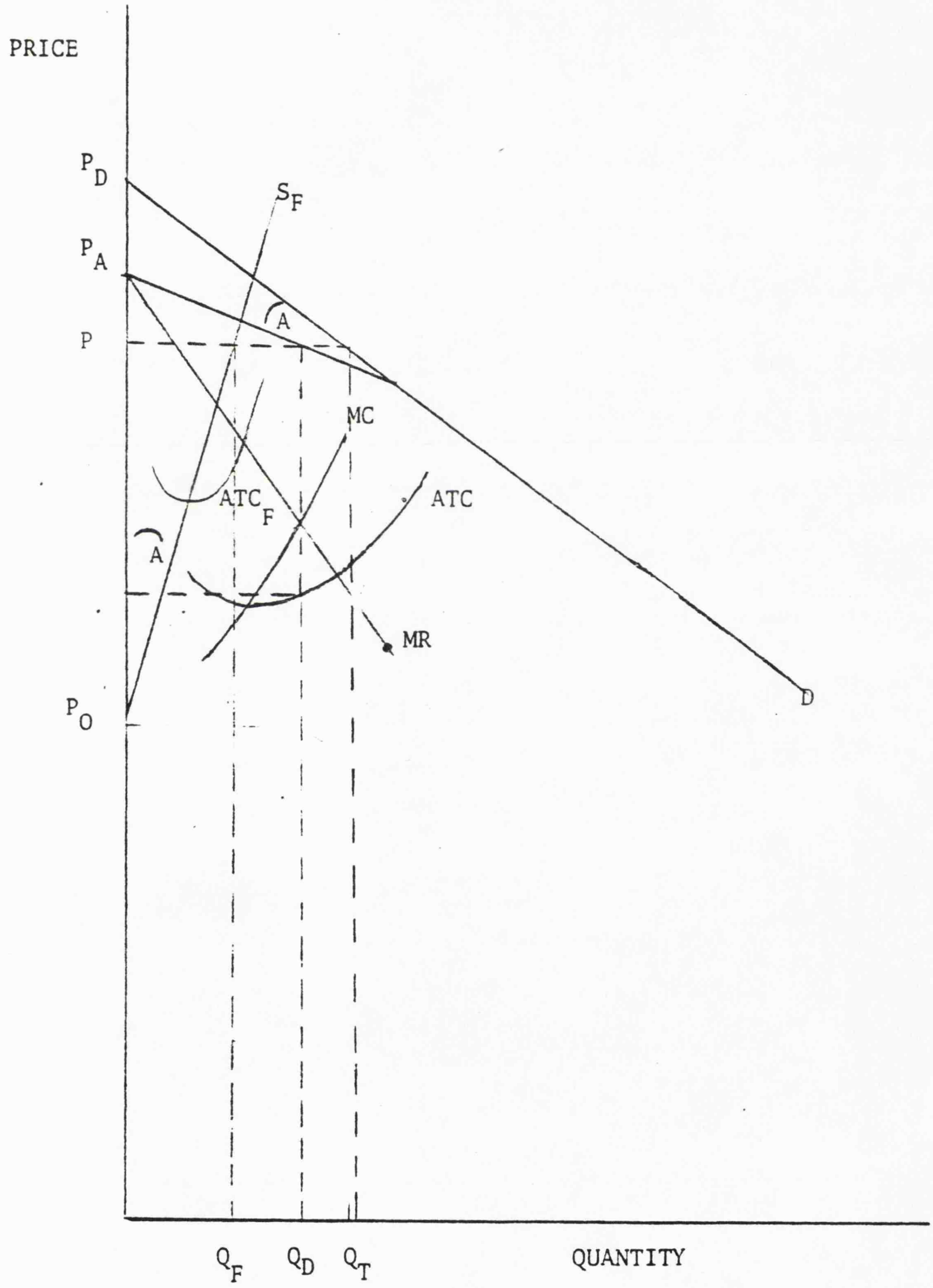
LIMIT PRICING: A DETAILED REVIEW FROM ECONOMICS

Small scale competitive threats

In dealing with the case of small scale, fringe competitors, who view the dominant firm's price as a given, the problem for the dominant firm is to choose the best price, from its own perspective, considering the likely output of the competitive fringe at whatever price it sets. A graphical description of the problem is shown in Figure A1-1, on the next page.

The total market demand is $P_D D$. The supply curve for all members of the fringe is $P_O S_F$. The competitive fringe supply curve is assumed linear to simplify construction. Clearly at a price of P_O or below, the fringe will supply nothing since price is below their minimum marginal cost, and at a price of P_A or above, the fringe will supply all the demand. Assuming the dominant firm knows the fringe supply function it will know how much the fringe will supply at each announced price, and therefore by difference from the total market demand curve, how much will be left for it to supply. By construction, angles "A" are equal. Hence, the dominant firm's residual demand curve is the kinked line $P_A D'D$ and its marginal revenue curve is $P_A MR$. The dominant firm can then equate marginal revenue and marginal cost, announce a price, P, produce a quantity Q_D and have profit equal to the area of the shaded rectangle. Similarly, the fringe competitors will accept the price, P, and produce Q_F, which equals Q_T-Q_D,

FIGURE A1-1. LIMIT PRICING UNDER SMALL SCALE THREAT



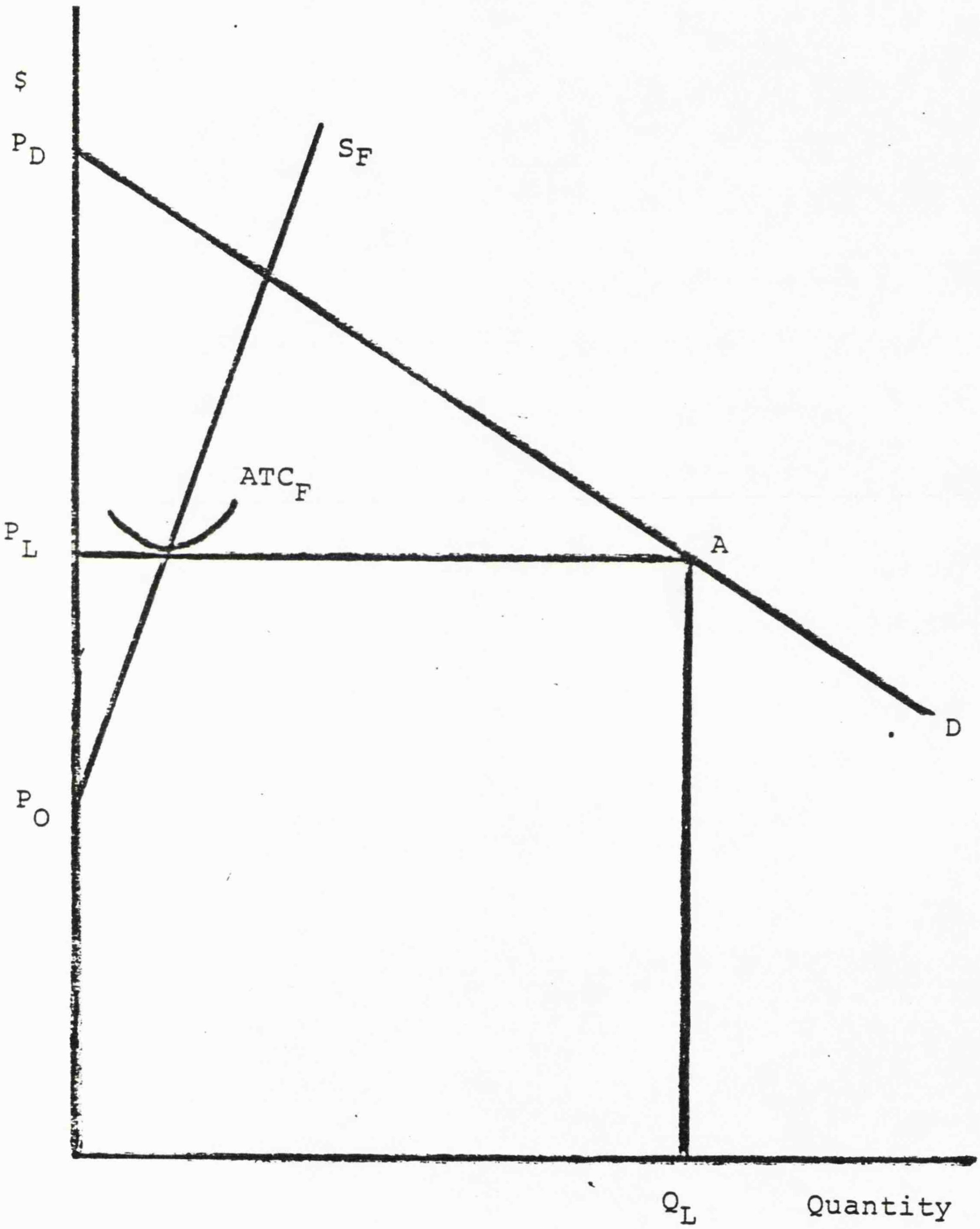
at least in the short run.

However, in the long-run, if the price is above the fringe competitors average total cost, ATC_F, the fringe will earn economic profit and will as time passes have an incentive to expand capacity. Also, potential fringe competitors will be attracted. The effect over time of such expansion and new entry will be to shift the fringe supply function downward and to the right thereby increasing the quantity supplied by the fringe, decreasing the dominant firm's long-run profits. This process will continue as long as the fringe producers average total cost is below the market price or until the fringe producers' share becomes so large that they can no longer ignore the effect their output decision has on price, i.e. they recognize their oligopolistic interdependence.

A simple way for the dominant firm to avoid this problem of erosion of market share by fringe competitors is to set a price at which the fringe is discouraged from expanding. Clearly though, this means a price that forgoes maximized short-run profits. Such a limit pricing strategy is shown in Figure A1-2 on the next page.

Assume that the dominant firm's residual demand curve is the line P_DAD, that is the amount supplied by the competitive fringe has been subtracted from the total market demand function. If the dominant firm is a monopolist, the line P_DAD then represents total

FIGURE A1-2. PRICING TO LIMIT SMALL SCALE EXPANSION



market demand. Assume that the conditions describing a threat to the market share of the dominant firm by the competitive fringe also apply; namely, their output is small individually when compared to market demand and they take the price set by the dominant firm as a given, unaffected by their output decision. Let P_L be the price that just equals the lower average total cost per unit, normal profit included, for the fringe competitors. If the dominant firm holds the price above P_L, existing fringe competitors will be encouraged to expand and potential fringe competitors will be encouraged to enter the market, because more than "normal" profits could be earned. If the dominant firm persists in holding the price above P_L, the fringe will continue to expand until the dominant firm's market share is essentially zero. Given that tendency by fringe competitors, the dominant firm's long-run demand curve becomes perfectly elastic at price P_L, if it wishes to deter market share loss to the competitive fringe. The effective demand curve for the dominant firm becomes the kinked line $P_L AD$, and the dominant firm must satisfy the market demand, Q_L, at the limit price, P_L.

The concept of a perfectly price elastic long-run demand curve over much of the relevant output range for a monopolist or the dominant firm in an oligopoly may require further theoretical support to be convincing. Clark (1940:248) was first to suggest that long-run demand schedules might:

"in numerous cases approach the horizontal so closely that the slope would not be a matter of material movement, in light of all the uncertainty involved."

Clark's work was followed by Heflebower (1954) and by Andrews (1964) who suggested that such elasticity is caused not only by the long-run threat of competitive entry but also from the long-run threat from competitive products. A simple description of the logic of the threat from competitive, or substitute products follows.

Essentially all products have substitutes -- steel for wood, aluminum for steel, engineering plastic for aluminum, etc. The consumer's choice between substitute products is affected by the product's cost-in-use which is determined by its physical properties and its price. Competition between substitutes caused by relative price changes is more intense in the long-run than in the short-run, caused by adjustment lags on both the demand and supply sides of the market The effect of these factors is to make market demand much more sensitive to price in the long-run. Such a high degree of demand elasticity effectively restrains the price the monopolist or oligopolistic group can charge without inviting sales losses through the substitution effect.

The profitability of a limit pricing strategy by the dominant firm depends upon how low the limit price, P_L, is when compared with his costs and what output quantity the dominant firm has designed his production facility to operate at most efficiently. Figure A1-3 on the next page assumes the dominant firm's minimum average total cost is reached at the quantity demanded at the limit price. Under these conditions and following a limit pricing strategy, the dominant firm will earn supranormal profits enclosed by the rectangle P_LABC. Using the same dominant firm cost functions, but assuming no threat to market share exists, the dominant firm would equate marginal revenue and marginal cost and set a price P_M, supply an output Q_M and earn supranormal profits enclosed by the rectangle P_MDEF. The profits earned at the short-run maximizing price, P_M, will exceed those earned at the limit price, P_L, at least in the short-run.

The decision that the dominant firm faces is then either higher short-run profits, declining over time as market share is eroded by the competitive fringe, or lower limit pricing profits, remaining constant over time as market share is maintained. Both assuming cost functions remain unvarying over time. Such a dilemma is shown in Figure A1-4, on the second following page.
The solution to the dilemma depends upon the discount rate applied to the cash flows that result from either strategy, and the rate at which the competitive fringe will expand output at the dominant firm's short-run profit maximizing price.

FIGURE A1-3. THE PROFIT OF A LIMIT PRICING STRATEGY

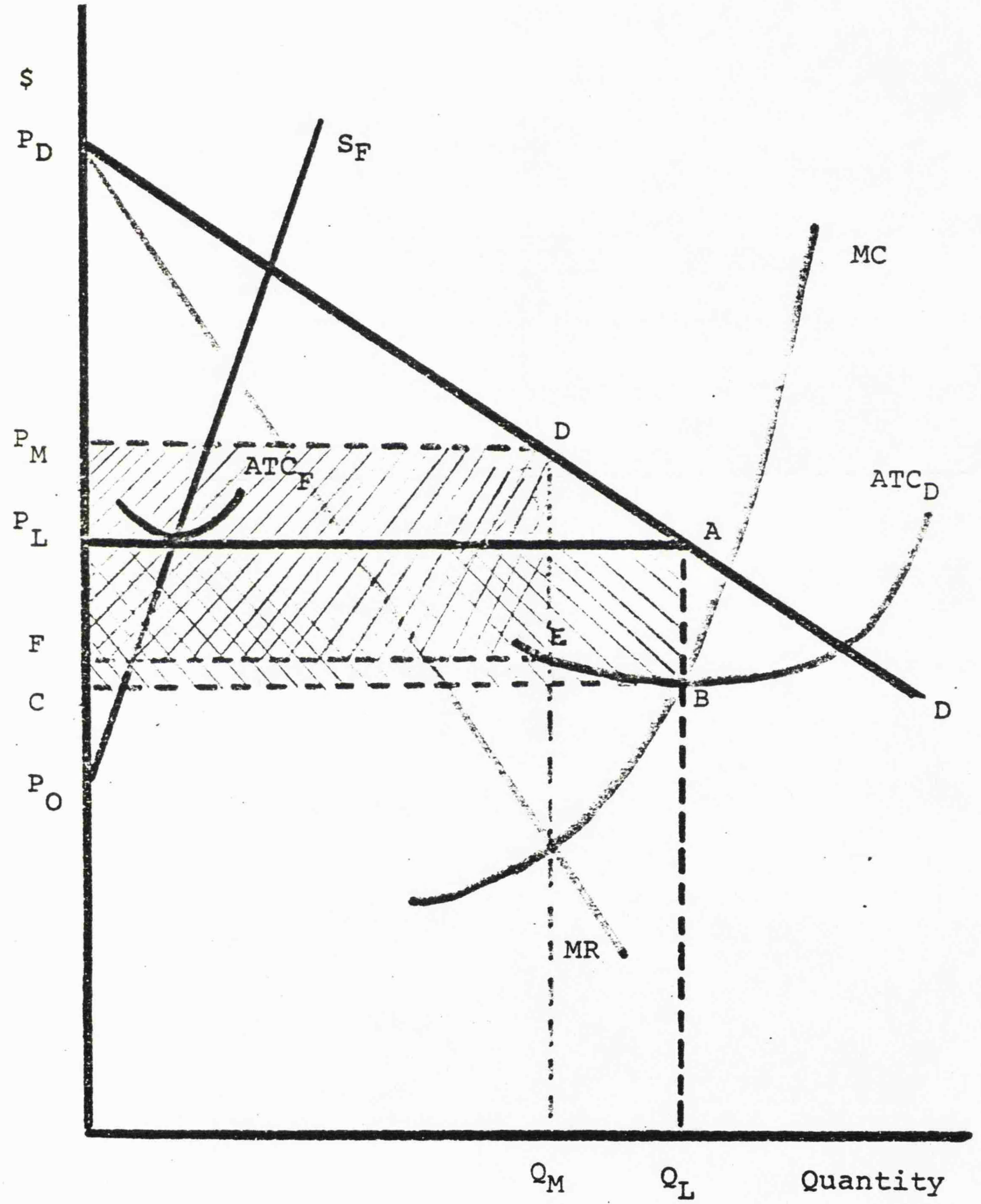
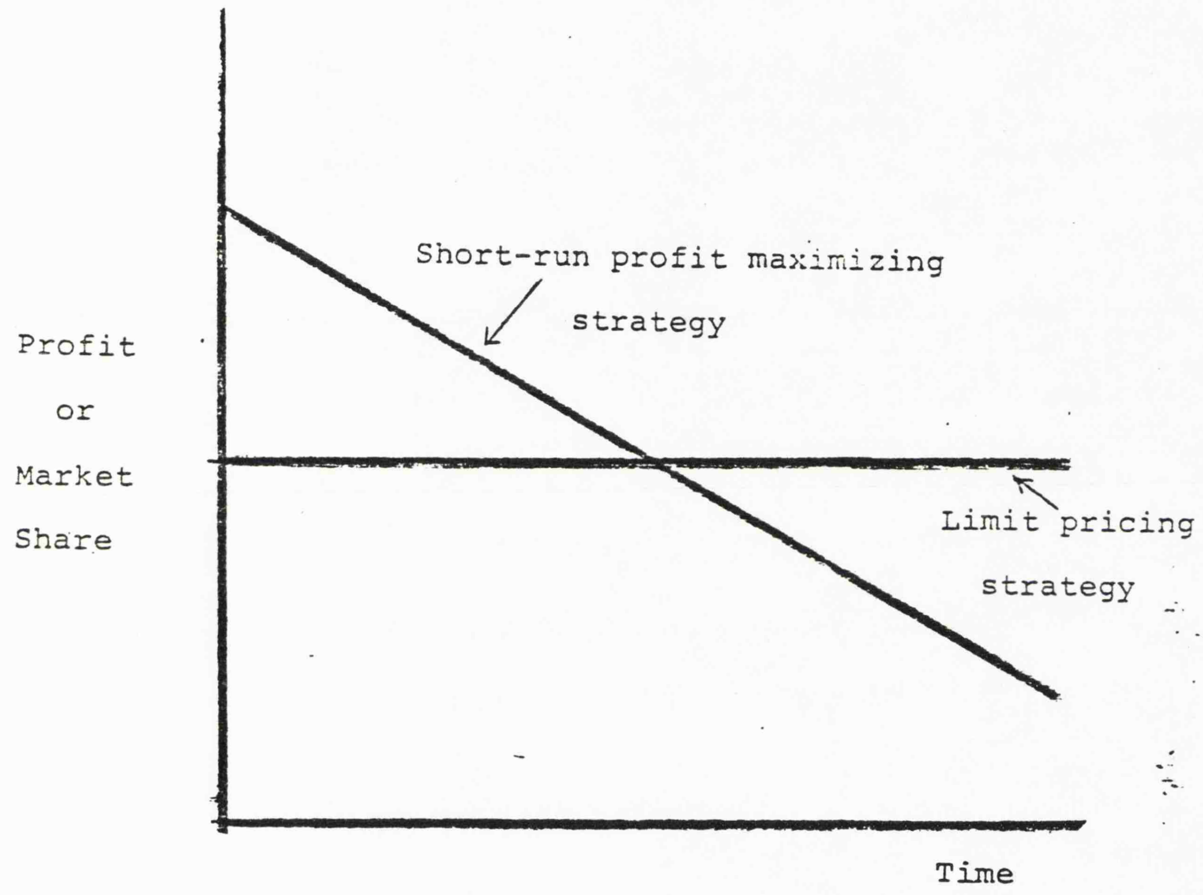


FIGURE A1-4. THE LIMIT PRICING VS. SHORT-RUN PROFIT MAXIMIZING TRADEOFF



Scherer (1980:237) explains the dynamics of expansion by and new entry into the competitive fringe, causing market share erosion to the dominant firm to be described by the simple differential equation:

$$dQ/dT = k\ [P_M(t) - P_L]$$

where dQ/dT is the rate of fringe expansion, k is the rate at which fringe competitors respond to the supranormal profit potential of a price higher than the limit price, and $[P_M(t) - P_L]$ describes the profit stimuli to the fringe, where $P_M(t)$ is the market price set by the dominant firm over time and P_L is the limit price required to maintain the dominant firm's market share. Depending on conditions in the market, e.g. a product in decline, and the rate of expansion by the fringe and the k factor in the differential equation above, the optimum strategy for the dominant firm may be to set a price above the limit price and allow market share to deteriorate.

Effects of the experience curve on limit pricing

A final, and extremely important, consideration is the effect the Boston Consulting Group's experience curve has on the strategic implications of limit pricing. All previous discussion on setting a limit price to deter both fringe and large scale erosion of market share assumed that the cost functions of both the dominant firm and new and potential entrants were static over time. In fact, the effect of the experience curve is that relative costs depend on total accumulated production volume. And, if a limit pricing strategy is successful in deterring expansion, the dominant firm's experience will grow faster than his competitors. The dominant firm's cost advantage will grow and the rewards of a limit pricing policy will increase over time.

Figure A1-5, on the next page, shows the effect of the experience curve on limit pricing for small scale or fringe competitors. Assume initially the dominant firm's long-run residual demand curve is given by the kinked line $P_L AD$, because P_L is the limit price set to discourage small scale entry. The dominant firm then producers quantity Q_L on its average total cost curve ATC_D and earns supranormal profits enclosed by the rectangle $P_L ABC$. Assume further that demand grows over time and the limit pricing strategy is successful in deterring capacity additions at the fringe. At this later point in time the dominant firm's residual demand curve becomes the kinked line P_L'DD'. The limit price required at the fringe has been assumed to fall to P_L' from P_L because the fringe producers' costs have declined with their added experience. However, the dominant firm's costs have declined even further to ATC_D' from ATC_D because the dominant firm has increased market share as the market grows and expansion of the fringe is zero. The dominant firm now produces quantity Q_L' and its profits explode to the area enclosed by the shaded rectangle P_L'DEF.

Figure A1-6, on the second following page, shows the effect of the experience curve on limit pricing to deter large scale entry. Recall, the limit price P_L is set by taking the potential large scale entrant's cost at his minimum operating scale (assumed to be the same as the

FIGURE A1-5. LIMIT PRICING TO DETER SMALL SCALE EXPANSION CONSIDERING THE EXPERIENCE CURVE

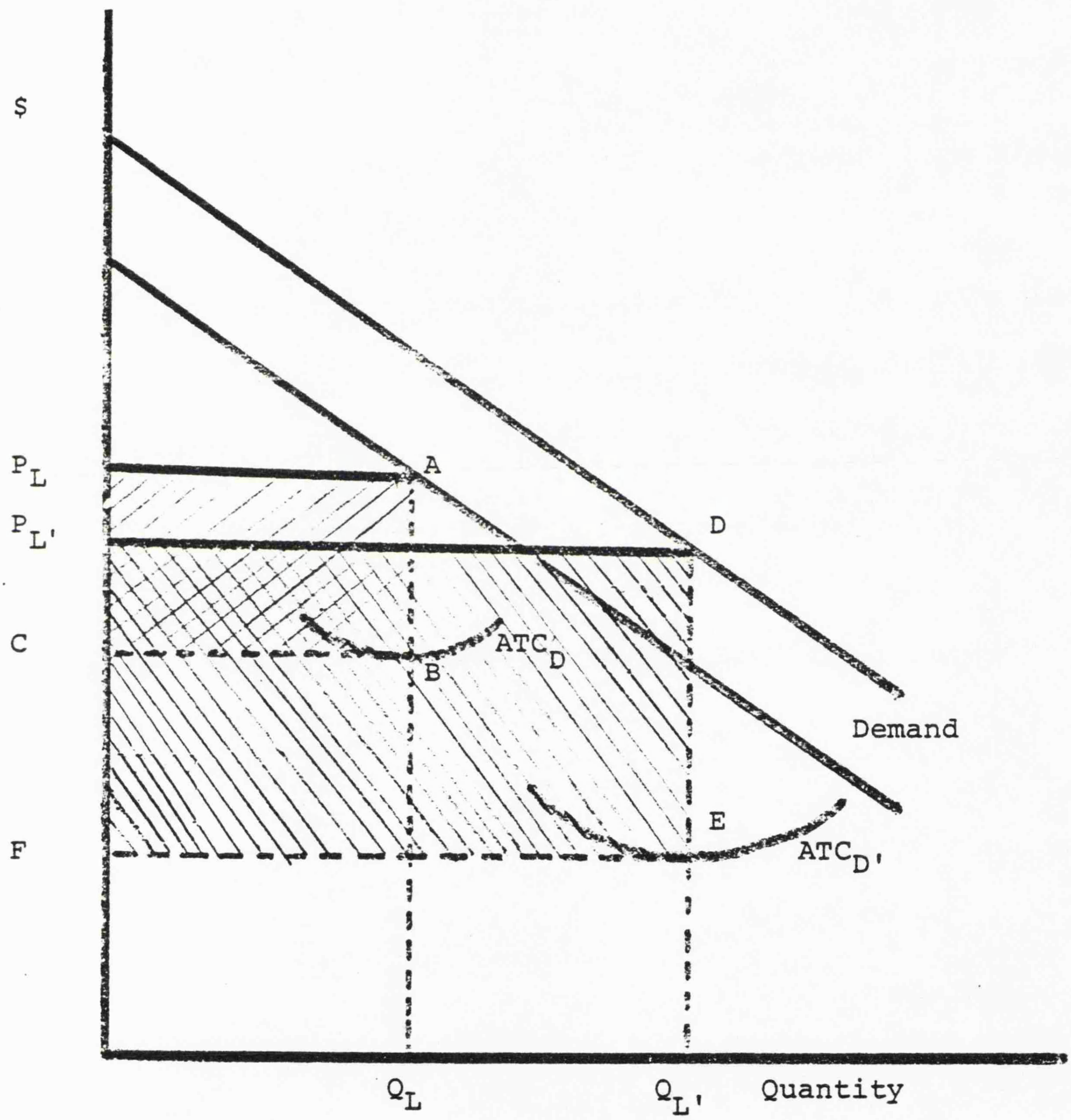
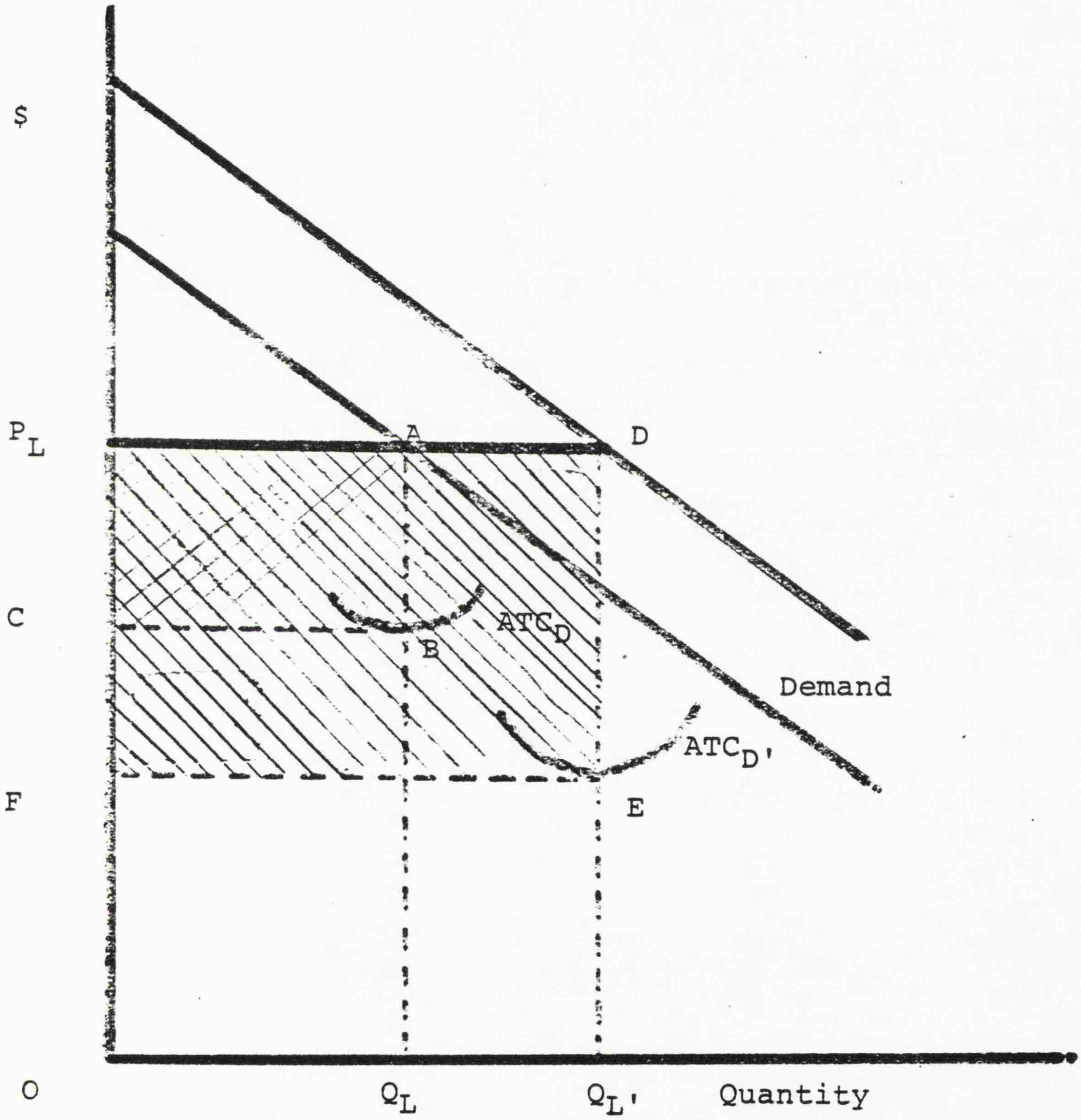


FIGURE A1-6. LIMIT PRICING TO DETER LARGE SCALE EXPANSION CONSIDERING THE EXPERIENCE CURVE



dominant firm's minimum average total cost), OC on the price-cost axis, and adding to it an amount slightly less than the market price would fall if the potential large scale producer entered at his minimum operating scale, CP_L on the price-cost axis. Given the conditions shown the dominant producers profits will be the area enclosed by the shaded rectangle P_LABC. As time passes, and assuming demand increases, the price required to limit large scale entry may remain P_L, because the potential entrance has accumulated no experience and his costs have not declined. However, the dominant firm's costs have not declined to ATC_D' due to experience; and its profits have exploded to the area of the shaded rectangle P_LDEF. Moreover, as long as entry is deterred, the dominant firm's cost advantage over the potential large scale new entrant will increase and the profit of such a strategy will grow. The above assumes that the Bain's limit price required, P_L, will not decline over time because the potential entrant's costs will not decrease because of the lack of the experience of production. It does seem reasonable that some of the dominant firm's cost reducing knowledge, gained from its experience, will "leak out" as production techniques become well known, as knowledgeable employees leave, as patents expire, and as a result of reverse engineering. If that occurs, P_L will decline over time and we face the exact conditions shown in Figure A1-5 and discussed earlier.

APPENDIX 2

CALCULATION OF COMPETITOR'S VIEW OF THE MARKET

YEAR	ANNUAL SALES VOLUME	ANNUAL SALES VOLUME DISCOUNTED AT 10%	15%	20%
1	100	100.0	100.0	100.0
2	200	181.8	173.9	166.7
3	300	247.9	226.8	208.3
4	400	300.5	263.0	231.5
5	500	341.5	285.9	241.2
6	600	372.5	298.3	241.1
7	700	395.2	302.6	234.4
8	800	410.4	300.7	223.3
9	900	419.9	294.2	209.3
10	1000	424.1	284.3	193.8
11	1100	424.1	271.9	177.7
12	1200	420.6	257.9	161.5
13	1300	414.2	243.0	145.9
14	1400	405.6	227.5	130.9
15	1500	395.0	212.0	116.9
16	1600	383.0	196.6	103.8
17	1700	369.9	181.7	92.0
18	1800	356.0	167.2	81.2
19	1900	341.8	153.5	71.4
20	2000	327.0	140.6	62.6
		7031.3	4581.6	3193.1

APPENDIX 3

DATA SOURCE FOR MAPPING RESULTS

DATA SOURCE FOR FIGURES 5-1 AND 5-8

$\underline{NPV = f\ (N, S_A),\ E_B = .75,\ R = .15}$

FIRM'S MARKET SHARE (%)

YR	90	80	70	60	50	40	30	20	10
1	947	884	538	-23	-795	-1801	-3105	-4840	-7360
2	845	767	424	-125	-882	-1874	-3168	-4904	-7443
3	776	700	374	-148	-871	-1827	-3087	-4798	-7336
4	720	649	346	-145	-829	-1741	-2954	-4621	-7137
5	670	607	327	-131	-773	-1636	-2796	-4408	-6883
6	624	569	312	-112	-712	-1524	-2624	-4173	-6589
7	579	533	298	-91	-647	-1406	-2443	-3920	-6263
8	536	497	285	-70	-582	-1284	-2254	-3652	-5908
9	492	461	272	-50	-515	-1160	-2059	-3370	-5523
10	448	424	257	-30	-449	-1035	-1857	-3073	-5108
11	403	385	240	-12	-384	-907	-1650	-2761	-4661
12	357	345	222	3	-320	-780	-1438	-2436	-4181
13	310	303	200	16	-259	-653	-1223	-2099	-3669
14	262	259	177	25	-201	-529	-1007	-1754	-3126
15	214	214	150	31	-148	-409	-794	-1405	-2558
16	165	167	121	33	-101	-298	-590	-1061	-1976
17	118	121	90	30	-62	-197	-401	-732	-1397
18	72	75	58	23	-31	-112	-234	-434	-848
19	32	34	27	12	-10	-45	-97	-184	-367

DATA SOURCE FOR FIGURE 5-7

<u>$NPV = f\,(N, S_A),\ E_B = .75,\ R = .30$</u>

FIRM'S MARKET SHARE (%)

N	90	80	70	60	50	40	30	20	10
1	1179	1216	937	418	-329	-1334	-2660	-4448	-7068
2	1055	1068	785	273	-465	-1460	-2782	-4579	-7227
3	968	975	706	220	-485	-1443	-2729	-4500	-7150
4	895	902	652	196	-468	-1380	-2616	-4339	-6963
5	829	837	607	183	-439	-1298	-2476	-4138	-6714
6	767	777	566	175	-403	-1209	-2323	-3915	-6425
7	719	736	540	134	-366	-1116	-2163	-3676	-6103
8	648	663	490	162	-328	-1021	-1997	-3423	-5753
9	591	606	452	156	-290	-925	-1825	-3159	-5375
10	533	549	413	149	-252	-827	-1649	-2881	-4969
11	475	492	373	141	-214	-727	-1468	-2591	-4534
12	418	435	333	132	-177	-627	-1282	-2288	-4067
13	359	376	292	122	-141	-526	-1092	-1974	-3570
14	301	317	249	110	-107	-427	-902	-1651	-3042
15	244	258	206	96	-75	-331	-713	-1324	-2491
16	187	200	162	80	-48	-240	-530	-1000	-1924
17	132	143	118	62	-25	-158	-359	-691	-1360
18	81	89	74	42	-9	-88	-208	-409	-825
19	36	40	34	21	0	-34	-86	-172	-356

DATA SOURCE FOR FIGURES 5-3 AND 5-9

$NPV = f\,(N, E_B),\ R = .15,\ S_A = 60\%$

COMPETITIOR'S EXPERIENCE CURVE SLOPE

N	85%	80%	75%	70%	65%
1	9914	3478	-23	-1868	-2806
2	9645	3260	-125	-1857	-2707
3	9394	3117	-148	-1782	-2565
4	9115	2992	-145	-1688	-2413
5	8800	2870	-131	-1586	-2258
6	8447	2742	-112	-1480	-2103
7	8052	2608	-91	-1372	-1948
8	7616	2463	-70	-1261	-1792
9	7136	2307	-50	-1149	-1635
10	6611	2139	-30	-1035	-1476
11	6042	1958	-12	-919	-1314
12	5428	1763	3	-802	-1151
13	4773	1555	16	-685	-987
14	4079	1334	25	-567	-822
15	3357	1102	31	-452	-659
16	2617	863	33	-341	-500
17	1878	623	30	-236	-349
18	1169	390	23	-141	-211
19	525	176	12	-61	-92

DATA SOURCE FOR FIGURE 5-12

$\underline{NPV= f\ (N,R),\ S_A=70\%,\ E_B=70\%}$

COMPETITOR'S VIEW OF THE PRODUCT LIFE CYCLE

N	.00	.05	.10	.15	.20	.25	.30
1	230	316	420	538	665	799	937
2	151	227	319	424	539	660	785
3	123	194	278	374	479	591	706
4	113	180	258	346	442	545	652
5	112	174	246	327	415	509	607
6	115	172	238	312	392	477	566
7	120	172	232	298	370	447	528
8	124	172	226	285	349	418	490
9	128	171	219	272	328	388	452
10	131	169	211	257	306	358	413
11	131	164	201	240	282	327	373
12	128	157	188	222	257	294	333
13	122	147	173	280	229	260	292
14	113	133	154	177	200	224	249
15	100	116	133	150	168	187	206
16	83	95	108	121	134	148	162
17	63	72	81	90	99	108	118
18	41	47	52	58	63	69	74
19	19	22	24	27	29	32	34

DATA SOURCE FOR FIGURES 5-3 AND 5-12

$NPV = f(S_A, E_B)$, $N=1$, $R=.15$

COMPETITOR'S EXPERIENCE CURVE SLOPE

S_A	85%	80%	75%	70%	65%
90	4366	2248	947	166	-289
80	6876	3079	884	-350	-1023
70	8680	3454	538	-1040	-1866
60	9914	3478	-23	-1868	-2806
50	10582	3162	-795	-2837	-3852
40	10611	2471	-1801	-3969	-5027
30	9829	1307	-3105	-5311	-6371
20	7863	-539	-4840	-6963	-7969
10	3712	-3637	-7360	-9177	-10029

DATA SOURCE FOR FIGURES 5-5 AND 5-14

$NPV = f(S_A, R),\ N=1,\ E_B=.75$

COMPETITOR'S VIEW OF THE PRODUCT LIFE CYCLE

S_A	.00	.05	.10	.15	.20	.25	.30
90	767	818	878	947	1021	1099	1179
80	627	699	785	884	990	1101	1216
70	230	316	420	538	665	799	937
60	-363	-268	-153	-23	117	266	418
50	-1150	-1051	-931	-795	-646	-490	-329
40	-2156	-2058	-1938	-1801	-1653	-1496	-1334
30	-3440	-3347	-3234	-3105	-2964	-2814	-2660
20	-5130	-5050	-4953	-4840	-4716	-4584	-4448
10	-7569	-7512	-7442	-7360	-7268	-7170	-7068

DATA SOURCE FOR FIGURES 5-3 AND 5-15

$\underline{NPV = f\ (E_B, R),\ N=1,\ S_A=60\%}$

COMPETITOR 'S VIEW OF THE PRODUCT LIFE CYCLE

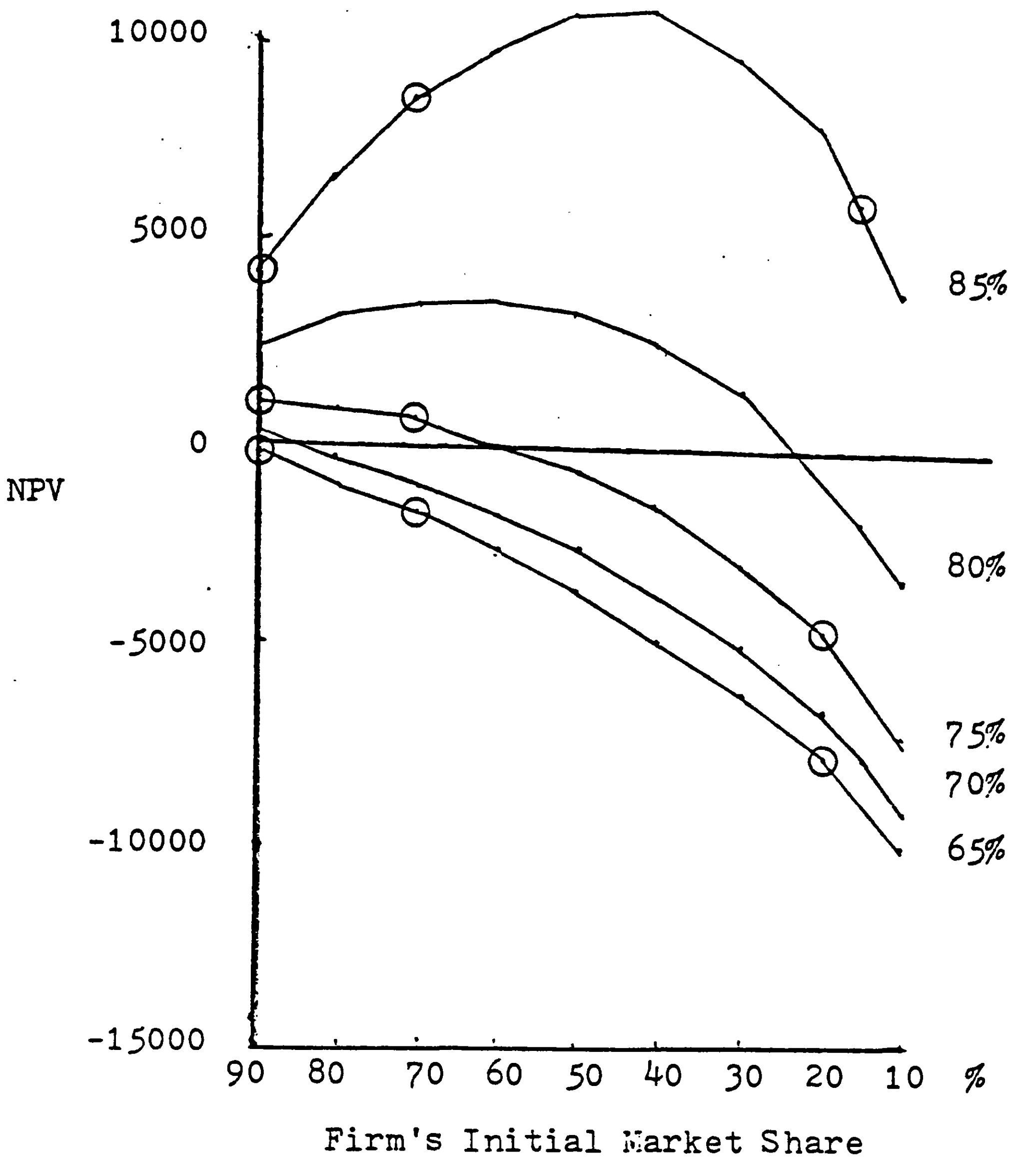
E_B	.00	.05	.10	.15	.20	.25	.30
85%	10629	10322	10078	9914	9836	9835	9900
80%	3341	3353	3398	3478	3589	3727	3885
75%	-363	-268	-153	-23	117	266	418
70%	-2171	-2081	-1979	-1860	-1753	-1638	-1523
65%	-3014	-2952	-2881	-2806	-2729	-2652	-2577

APPENDIX 4

THE EFFECT OF PRICE ELASTICITY OF DEMAND = 0 ON THE FIRM'S NPV

To understand the effect of the built-in assumption of the model of zero price elasticity of demand on the firm's NPV, it is useful to analyze the apparent anomaly of increasing NPV as the firm's experience curve slope advantage varies. This phenomenon was first discussed in Figure 5-3, which is reproduced below as Figure A4-1.

FIGURE A4-1. NPV =f(FIRM'S INITIAL SHARE) AT VARIOUS E_B, R = .15, N = 1



To understand Figure A4-1 I have analyzed in detail the calculation of NPV at E_B = 75%, 65% and 85% and S_A = 90%, 70%, and 20%. The results are summarized in Figure A4-2.

FIGURE A4-2. NPV RESULTS AT VARIOUS E_B AND S_A

E_B	S_A	"PRICE"	NPV_{OP}	NPV_{INV}	NPV_{TOT}
75%	90%	2.834	1152	-205	947
75%	70%	1.595	1186	-648	538
75%	20%	0.590	-2708	-2132	-4840
65%	90%	0.864	-85	-204	-289
65%	70%	0.388	-1221	-645	-1866
65%	20%	0.117	-5840	-2129	-7969
85%	90%	8.279	4568	-202	4366
85%	70%	5.683	9329	-649	8680
85%	20%	2.511	9992	-2129	7863

The columns E_B and S_A simply locate nine points on the family of curves shown in Figure A4-1. Those nine points are circled. The column entitled "Price" is really the cost multiplier on the firm's cost (described in detail in the section entitled "Model Logic") calculated to set a price where the competitor finds expansion unattractive based on incremental economics. For example, a "Price" of 2.834 where E_B = 75% and S_A is 90% means a price 2.834 times the firm's cost discourages competitive expansions. Clearly, the larger the "price" number the larger the firm's earnings, but not necessarily the larger the firm's incremental earnings. More on this in the next figure. The column NPV_{OP} is the firm's discounted incremental earnings from its strategy of discouraging competitive expansion. The column NPV_{INV} is the present value of the firm's investment in building additional capacity. The number is always negative because only the cost not the benefit of such investment is counted in NPV_{INV}. Clearly, the lower the firm's initial market share, the greater the cost of the investment of a strategy of preempting all market growth. Due to rounding in my calculations, the NPV_{INV} numbers vary very slightly. For example at S_A of 90%, NPV_{INV} is -205 for E_B = 75% and at the same share at E_B = 85%, NPV_{INV} is -202 . Conceptually, NPV_{OP} varies only with S_A and not with E_B. The column NPV_{TOT} is simply the sum of NPV_{OP} and NPV_{INV} and is the value graphed on the y-axis in Figure A4-1.

We might expect NPV_{OP} to grow as share grows. However when E_B = 85%, NPV_{OP} declines as share grows. More analysis is required!

Again, NPV_{OP} measures the firm's incremental discounted earnings from a strategy of preempting all market growth by discouraging competitive expansion. Such a value is determined by the difference in earning between the stated strategy and only growing with the market. For analysis, I have calculated actual price and unit earning under a number of circumstances, as shown in Figure A4-3.

FIGURE A4-3. PRICE AND UNIT EARNINGS AT VARIOUS E_B AND S_A

				FIRM'S UNIT EARNINGS IF FIRM:			
E_B	S_A	PRICE		EXPANDS SHARE		DOESN'T EXPAND SHARE	
		YR 1	YR 20	YR 1	YR 20	YR 1	YR 20
75%	90%	77.00	8.05	49.83	5.21	49.83	5.10
75%	70%	48.09	4.56	17.94	1.70	17.94	1.28
75%	20%	29.92	1.72	-20.80	-1.20	-20.80	-3.79
85%	90%	224.94	23.51	197.77	20.67	197.77	20.56
85%	70%	171.34	16.25	141.19	13.39	141.19	12.97
85%	20%	127.36	7.33	76.64	4.41	76.64	1.82

As previously mentioned, NPV_{OP} is a function of the difference in unit earnings between a strategy of preempting all market growth versus growing with the market. Note the case where E_B = 85%. At 90% share the difference in unit earnings is only 0.11 after 20 years, while at 20% the difference is 2.59. However, when E_B = 75%, exactly the same differences in unit earnings appear. If there is no differences in unit earnings when

E_B varies, and there is no difference in sales volumes if initial market shares are equal, why is there such a difference in incremental discounted earnings (NPV_{OP}) as shown in Figure A4-2? The answer must be the large differences in the price (really the price pattern) required to discourage competitive expansion. Figure A4-4 shows selected calculations to illustrate the point.

FIGURE A4-4. SELECTED CALCULATIONS OF NPV_{OP} AS A FUNCTION OF E_B AND S_A

CASE 1: S_A= 70%, E_B= 85%, PRICE = $171.34, WHEN N=1

	FIRM EXPANDS SHARE			FIRM DOESN'T EXPAND SHARE			
							DELTA
		EARNINGS			EARNINGS		NET
YR	SALES	UNIT	NET	SALES	UNIT	NET	EARNINGS
1	70	141.19	4942	70	141.19	4942	0
2	170	84.67	7197	140	83.64	5854	1343
3	270	61.91	8358	210	60.80	6384	1974
4	370	49.36	9132	280	48.30	6762	2364
5	470	41.30	9706	350	40.32	7056	2650

CASE 2: S_A= 70%, E_B= 75%, PRICE = $48.09, WHEN N=1

	FIRM EXPANDS SHARE			FIRM DOESN'T EXPAND SHARE			DELTA
		EARNINGS			EARNINGS		NET
YR	SALES	UNIT	NET	SALES	UNIT	NET	EARNINGS
1	70	17.94	628	70	17.94	628	0
2	170	10.76	915	140	9.73	681	234
3	270	7.87	1062	210	6.77	711	351
4	370	6.27	1160	280	5.21	729	431
5	470	5.25	1234	350	4.28	749	495

CASE 3: S_A= 20%, E_B= 85%, PRICE = $127.36, WHEN N=1

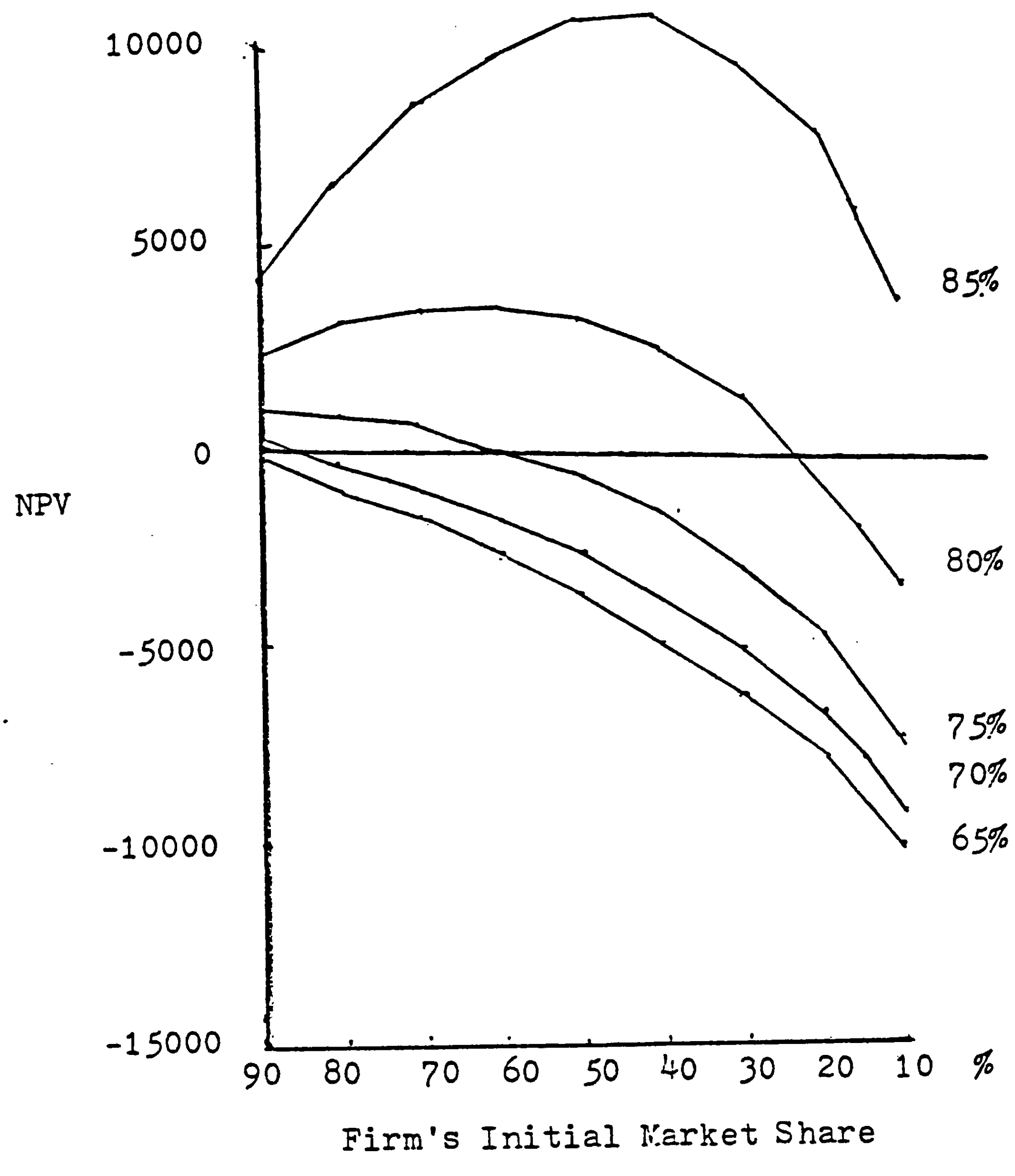
	FIRM EXPANDS SHARE			FIRM DOESN'T EXPAND SHARE			DELTA
		EARNINGS			EARNINGS		NET
YR	SALES	UNIT	NET	SALES	UNIT	NET	EARNINGS
1	20	76.64	766	20	76.64	766	0
2	120	34.16	2050	40	24.62	492	1558
3	220	23.09	2540	60	14.26	428	2112
4	320	17.74	2838	80	9.98	400	2438
5	420	14.52	3049	100	7.65	383	2666

The "sales" column when the firm elects to expand share is simply determined from the standard product life cycle assumed in this thesis (i.e. industry sales in year 1 are 100, year 2 200, etc.), the firm's initial market share, 70% under the first condition and the policy of discouraging competitive expansion. The "sales" column when the firm elects to maintain market share is simply the industry sales as above times the firm's initial market share. The "unit earnings" column is simply the difference between the price required to discourage competitive expansion and the firm's cost under each option. The "net earnings" column is simply the "sales" column times the "unit earnings" column times one minus the tax rate (50%). The incremental net earnings column is the difference between the "net earnings" column if the firm elects to expand its share and the "net earnings" column if the firm expands with the market.

Recall, the purpose of this appendix is to explain the apparent anomaly of increasing NPV as the firm's initial share declines, when the firm has an experience curve slope advantage. As a memory refresher, I have reproduced Figure A4-1, on the next page.

Looking at the "incremental net earnings" columns for Case 1 and Case 2 clearly shows incremental net earnings are substantially higher when E_B = 85%, that is an investment by the firm in increased market share is more attractive if the firm has an experience curve slope advantage. This occurs even though sales volumes are the

FIGURE A4-1. NPV = (FIRM'S INITIAL SHARE) AT VARIOUS E_B, R=.15, N=1



same under each case and the difference in unit earnings are the same under each case. The reason for the higher incremental net earnings is the much high initial price in Case 1 (\$171.34) compared to Case 2 (\$48.09). However, the "sales" columns for both cases are identical. The built-in assumption of the model is therefore that the price elasticity of demand is zero. In other words, the firm's sales are independent of the price charged.

Looking at the "incremental net earnings" columns for Case 1 and Case 3 clearly shows incremental net earnings is higher when the firm has a lower initial market share. The main reason here is significantly higher incremental sales volume when $S_A = 20\%$, but also a significantly different price. The initial price in Case 1 is $141.19 versus $76.64 in Case 3.

The conclusion must be that the firm's NPV of a strategy of preempting all market growth through a price strategy is heavily dependent on the price elasticity of demand functions. The closer an actual product is to zero elasticity, the more representative the results portrayed in this thesis.

APPENDIX 5

MODEL LOGIC AND INPUT DATA

MODEL LOGIC

```
FILE  4(KIND=DISK,TITLF="HOLLAND/DATA1",FILETYPE=7,NEWFILE=FALSE)
FILE  5(KIND=DISK,TITLF="PAUL/TEST",FILETYPE=7)
FILE  6(KIND=PRINIER)
REAL NEPUB,NEPUC,NEUB,NEUC,NEA,NEC
DIMENSION  V(20),VA(20),SVA(20),VB(30),SVB(20),COSTA(20),
*          COSTB(20),NEPUB(20),NEPUC(20),NEUB(20),NEUC(20),
*          VC(20),VD(20),SVC(20),SVD(20),COSTC(20),COSTD(20),
*          FP1(20),F1(20),F2(20),NEA(20),NEC(20),F3(20),
*          CEA(20),CMA(20),SA(20),SB(20),EA(20),EB(20),R(20)
READ(5,/) (V(B),B=1,20)
READ (5,/)(SA(I),SB(I),I=1,9)
READ (5,/)(EA(J),EB(J),J=1,5)
READ (5,/)(R(K),K=1,7)
DO 999 I=1,9
DO 999 J=1,5
DO 999 K=1,7
%WRITE(6,/)SA(I),SB(I),EA(J),EB(J),R(K)
%WRITE(4,/)SA(I),EB(J),R(K)
1 FORMAT(F2.1,F7.1,F3.1,)
X=20
U=175.84
N=0
110 N=N+1
IF  (N.GT.19) GO TO 999
VW-0
VX=0
IF (N.LE.1) GOTO  98
DO 80 T=1,N-1
VA(T)=V(T)*SA(I)
SVA(T)=VA(T)+VW
VW=SVA(T)
VB(T)=V(T)*SB(I)
SVB(T)=VB(T)+VX
VX=SVB(T)
80  CONTINUE
98  DO 10  T=N,X
VA(T)=V(T)*SA(I)
SVA(T)=VA(T)+VW
VW=SVA(T)
VB(T)=V(T)*SB(I)
SVB(T)=VB(T)+VX
VX=SVB(T)
COSTA(T)=U*VW**EA(J)
COSTB(T)=U*VX**EH(J)
NEPUB(T)=COSTA(T)*VB(T)*0.5
NEUB(T)=COSTB(T)*VB(T)*0.5
10 CONTINUE
VY=0
VZ=0
```

```
      IF (N.LE.1) GOTO 99
      DO 70 T=1,N-1
      VC(T)=V(T)*SA(I)
      SVC(T)=VC(T)+VY
      VY=SVC(T)
      VD(T)=V(T)*SB(I)
      SVD(T)=VD(T)+VZ
      VZ=SVD(T)
      70 CONTINUE
      99 DO 20 T=N,X
      VD(T)=V(N)*SB(I)
      IF (VD(T).GE.V(T)*SB(I)) GO TO 100
      VC(T)=V(T)-VD(T)
      GOTO 101
      100 VC(T)=V(T)*SA(I)
          VD(T)=V(T)*SB(I)
      101 SVC(T)=VC(T)+VY
          VY=SVC(T)
          SVD(T)=VD(T)+VZ
          VZ=SVD(T)
      COSTC(T)=U*VY**EA(J)
      COSTD(T)=U*VZ**EB(J)
      NEPUC(T)=COSTC(T)*VD(T)*.5
      NEUC(T)=COSTD(T)*VD(T)*.5
      20 CONTINUE
      F11=0
      F22=0
      FP11=0
      DO 30 T=N,X
      FP1(T)=(NEPUB(T)-NEPUC(T))/(1.+R(K))**(T-N+1.)
      FP11=FP1(T)+FP11
      F1(T)=(NEUB(T)-NEUC(T))/(1.+R(K))**(T-N+1)
      F11=F1(T)+F11
      30 CONTINUE
      DO 40 T=N,X-1
      IF(VB(T+1)-VB(T)) 201,201,202
      201 F2(T)=0
      GOTO 203
      202 F2(T)=(VB(T+1.)-VB(T))*COSTB(T+1.)*0.5/(1.+R(K))**(T-N+1.
      203 F22=F2(T)+F22
      40 CONTINUE
      P=(F22+F11)/FP11
      F33=0
      DO 50 T=N,X
      NEA(T)=(COSTA(T)*(P-1.))*VA(T)*0.5
      NEC(T)=(COSTC(T)*(P-1.))*VC(T)*0.5
      F3(T)=(NEC(T)-NEA(T))/(1.+0.15)**(T-N+1.)
      F33=F3(T)+F33
      50 CONTINUE
      CEAT=0
      CMAT=0
      DO 60 T=N,X-1
      IF(VA(T+1)-VA(T))301,301,302
      301 CEA(T)=0
```

```
GO TO 303
302 CEA(T)=(VA(T+1)-VA(T))*COSTA(T+1)*0.5/(1+0.15)**(T-N+1)
303 CEAT=CEA(T)+CEAT
IF (VC(T+1)-VC(T)) 401,401,402
401 CMA(T)=0
GO TO 403
402 CMA(T)=(VC(T+1)-VC(T))*COSTC(T+1)*0.5/(1+0.15)**(T-N+1)
403 CMAT=CMA(T)+CMAT
60 CONTINUE
NPVA=(F33+CEAT-CMAT)
%WRITE(6,152)N,P,NPVA
WRITE(4,/)SA(I),EH(J),R(K);
WRITE(4,/)N,NPVA
152 FORMAT(3X,"N=",I2,10X,"PRICE=",F7.3,10X,"NPVA=",I15
153 FORMAT(I2,I15)
GOTO 110
999 CONTINUE
LOCK (4)
STOP
END
```

INPUT DATA

PAUL/TEST (05/31/84)

```
100,200,300,400,500,600,700,800,900,1000,1100,1200,1300,
1400,1500,1600,1700,1800,1900,2000
.1,.9,.2,.8,.3,.7,.4,.6,.5,
.5,.6,.4,.7,.3,.8,.2,.9,.1
-.41504,-.41504,-.41504,-.51457,-.41504,
-.32193,-.41504,-.62149,-.41504,-.23447
.30,.25,.20,.15,.10,.05,.00
```

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DEFINITION OF VARIABLES AFFECTING NPV

This thesis assumes that the NPV to the firm of further investment in an SBU is a function of four variables:

$$NPV = f(\ N,\ S_A,\ E_B,\ R\ )$$

The purpose of this section is to provide a handy place to refer to the definition of each variable, to aid in reading this thesis.

1. <u>N : the year in the product life cycle.</u>

N may vary from one to twenty because the "standard" product life cycle is limited to twenty years. N is the surrogate for the BCG matrix "growth" axis, since the position in the product life defines industry sales growth.

2. <u>S_A : the firm's initial market share.</u>

S_A may vary in ten percentage point increments from 10% to 90% in the model. It measures the firms current (an past) market share before a strategy of preempting all market growth, i.e., gaining market share, begins. In this two participant model the firm's initial market share (S_A) and the competitor's initial market share (S_B) always add to 100%.

3. E_B : the competitor's experience curve slope.

E_B varies in five percentage point increments from an experience curve slope of 15% to 35%. When E_B is 65% the competitor's costs decline 35% for each doubling of cumulative production volume. When E_B is 85% costs only decline 15% on the same basis. Since the firm's experience curve slope (E_A) is always held constant in the model at 75%, E_B also defines relative experience curve slope advantages. For instance, when E_B is 65% the competitor has a large cost advantage. When E_B is 85% the firm has a large advantage.

4. R : the competitor's required rate of return.

R varies in five percentage point increments from 0% to 30%. R is a surrogate for the competitor's view of the size of the product life cycle. When R is 0%, it appears to the firm that the competitor is willing to invest in the SBU at an IRR of 0%, using the firm's estimate of the shape, length and size of the product life cycle to predict future sales. Since both the firm and the competitor are assumed to have a 15% cost of capital and both act rationally, the competitor must see a larger product life cycle than does the firm to justify investment. Therefore, when R is less than 15%, the competitor sees a more attractive product. When R is more than 15% a less attractive one, and when R equals 15% both participants view the market identically.